California Institute of Technology
Department of Electrical Engineering

EE 163B
Communication Theory II

Spring 2005

http://ee163.caltech.edu

Midterm Exam 4-28-2005

This is an open book and notes, but closed friends, family, and neighbors exam. You are permitted to use online resources, as long as it does not involve requests for help of any type, through email, chat rooms, instant messaging, etc, from other actual human beings (except me, the instructor). You do not need to sit through the exam at once, and can take breaks, go out, eat, sleep, watch Saturday Night Live, ... as long as the total amount of time you spend on solving the problems is around 6-7 hours.
All the work in this exam is mine alone. I have neither received assistance from another person or group, nor have I given assistance to another person.

Name: _____ **Signature/Date:** _____

1. (15) Determine the PDF of the maximum likelihood phase estimate in Eq. 6.2-38 (p. 348).
2. (20) Problem 9.11 in your text (p. 592).
3. (20) Problem 9.22 in your text (p. 594).
4. (15) Problem 10.16 in your text (p. 655).
   Hint:
   $$\int e^{ax}\cos^n bx\,dx = \frac{1}{a^2+n^2b^2}\left[(a\cos bx + nb\sin bx)e^a x\cos^{n-1} bx + n(n-1)b^2\int e^{ax}\cos^{n-2} bx\,dx\right]$$
5. (20) Problem 10.24 in your text (p. 658).
6. (10) A QPSK receiver using rectangular pulse shaping is shown in Fig. P6-1. The system operates over an AWGN channel with an unknown phase offset and uses a 10 bit training sequence for phase estimation and synchronization followed by 1,000 information bits. A number of different signals are measured at various points in the receiver, denoted by numbers in gray circles, and the results are shown in Fig. P6-2. Eight samples were taken for each symbol, i.e., the oversampling factor is eight, and all time axes refer to the sample number (and not the symbol number). $E_b/N_0 = 10$ dB for all measurements unless otherwise noted.
   (a) Pair the plots A–D in Fig. P6-2 with the corresponding measurement points in Fig. P6-1. Explain your answers!
   (b) Study the plots in Fig. P6-2. What do you think is the main reason for the receiver's poor performance as compared to the theoretical curve? Why? Which box in Fig. P6-1 should be improved upon?
   (c) Explain how plot E was obtained and what can be concluded from it. Which, one, or several, of the measurement points in Fig. P6-1 was used for this plot, and how?

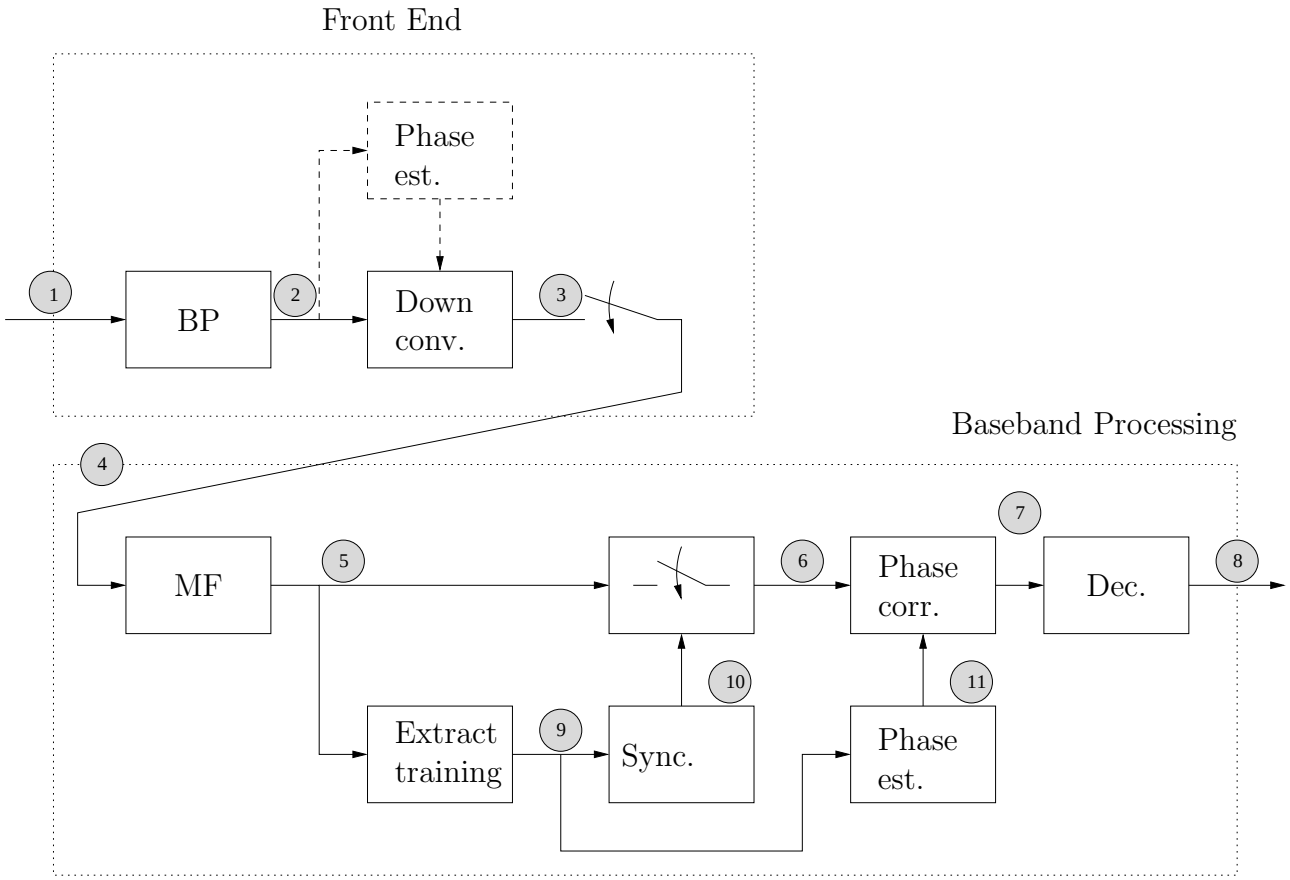
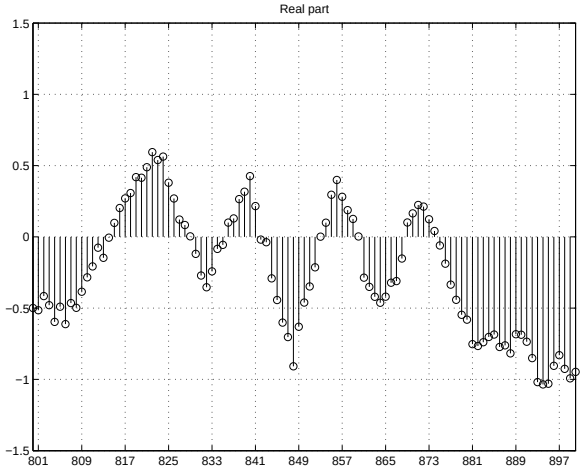
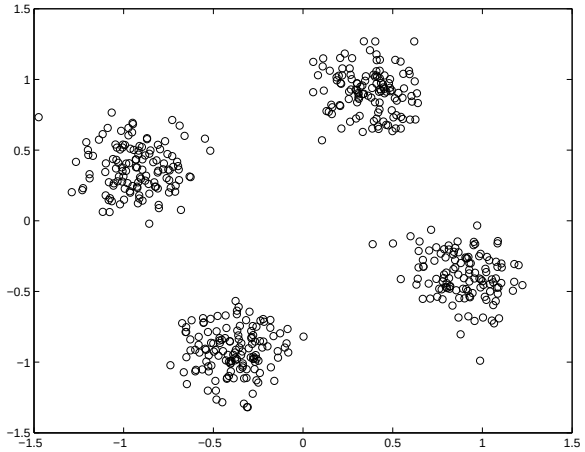

Front End
Phase
est.
1
BP
2
Down
conv.
3
Baseband Processing
4
MF
5
6
Phase
corr.
7
Dec.
8
10
11
Extract
training
9
Sync.
Phase
est.

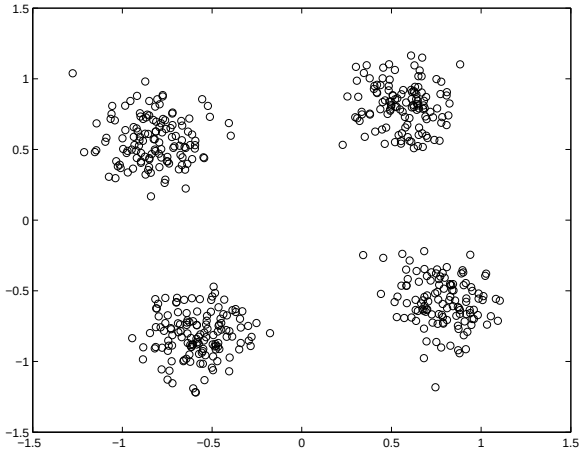
Figure P6-1.



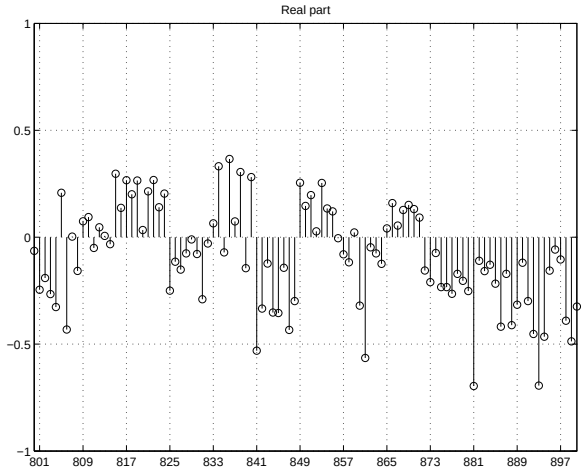
A



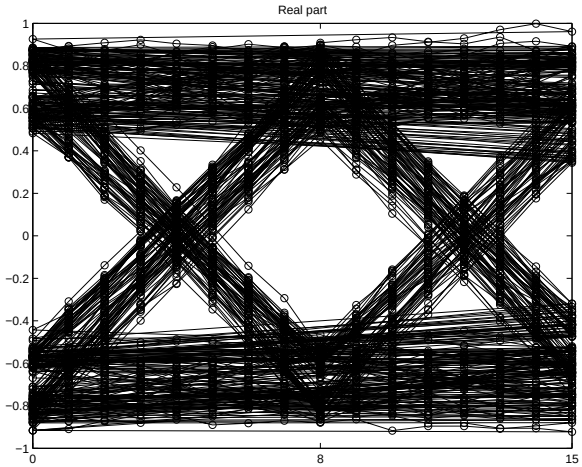
B



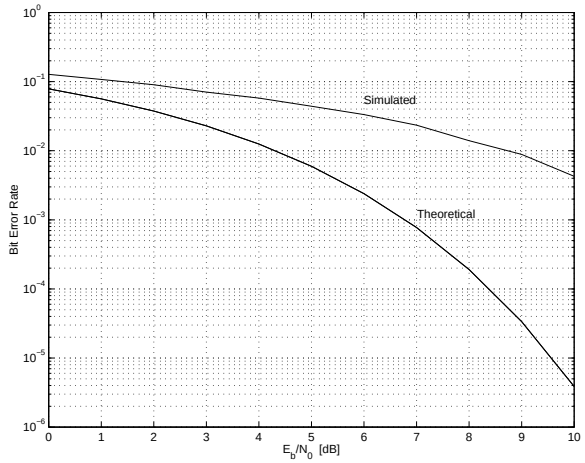
C



D



E (E_b/N_0=20 dB)



BER

Figure P6-2.