Name: ______________________

GTID: ______________________

ECE 6390: Satellite Communications and Navigation Systems
TEST 3 (Fall 2005)

- Please read all instructions before continuing with the test.
- This is a **closed** notes, **closed** book, **closed** friend, **open** mind test. On your desk you should only have writing instruments and a calculator.
- Show all work. (It helps me to give partial credit.) Work all problems in the spaces below the problem statement. If you need more room, use the back of the page. DO NOT use or attach extra sheets of paper for work.
- Work intelligently – read through the exam and do the easiest problems first. Save the hard ones for last.
- All necessary mathematical formulas are included either in the problem statements or the last page of this test.
- You have 50 minutes to complete this examination. When the proctor announces a "last call" for examination papers, he will leave the room in 5 minutes. The fact that the proctor does not have your examination in hand will not stop him.
- I will not grade your examination if you fail to 1) put your name and GTID number in the upper left-hand blanks on this page or 2) sign the blank below acknowledging the terms of this test and the honor code policy.
- Have a nice day!

Pledge Signature: ______________________________________

I acknowledge the above terms for taking this examination. I have neither given nor received unauthorized help on this test. I have followed the Georgia Tech honor code in preparing and submitting the test.

1. **Short Answer Section (15 points)**

   (a) ________________
   A [*Answer*] code is considered to be the best type of forward error correction.

   (b) ________________
   What type of earth orbit is a GPS satellite?

   (c) ________________
   Small perturbations and uncertainties in the orbital position of a satellite are called [*Answer*] errors.

   (d) ________________
   A measure of how much a CDMA receiver can reject ("spread out") noise and interference is called [*Answer*] gain.

   (e) ________________
   A GPS [*Answer*] is a group of 4 active satellites in a common orbit with 55° of inclination.

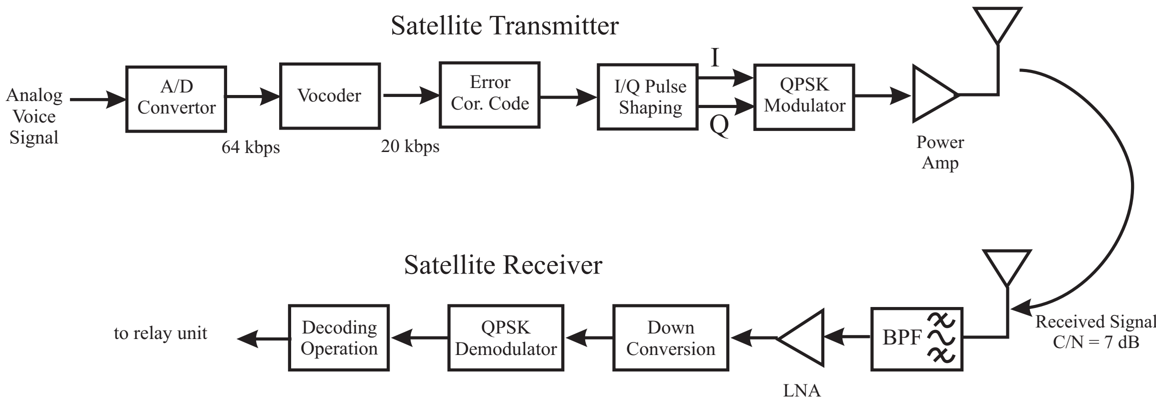
   (f) ________________
   The coding [*Answer*] of a system is the reduction in C/N required for a coded link to achieve the same BER as an uncoded link.

   (g) ________________
   The [*Answer*] filter is the optimum method for detecting a digital pulse.

2. **One Big Communications Link Design:**

   Below is a block diagram of a digital voice link in a satellite telephone system. The transmitter – a portable handset – samples and quantizes a voice system, runs the raw digital stream through a *vocoder* (a form of compression that minimizes the total number of bits sent by taking advantage of redundancies in normal human speech), adds forward error correction coding, and transmits the digital sequence with $\frac{\pi}{4}$-QPSK. The receiver – the satellite – demodulates this signal and relays it back to earth and into the PSTN (public switched telecommunications network). In the absence of interference, the typical C/N at the receiver is 7 dB. Answer the following questions based on this scenario. (**85 points**)

   Note: when a question below asks about an *uncoded* link, you are to analyze the system assuming that the forward error correction block has been removed.



(a) If the SNR of the digitized signal is 48 dB at the transmitter, what type of quantization is used? (5 points)

(b) Given your answer in (a), what is the maximum frequency content of the audio signal that we can transmit without aliasing in this system? (5 points)

(c) If the system is uncoded, what is the raw BER? (10 points)

(d) Draw a block diagram of the modulator unit at the transmitter. (10 points)

(e) If the system employed a BCH (128,256) block coder and all of the other parameters of the link design (coded bit rate, QPSK modulation scheme, etc.) are held constant, how much additional bandwidth must be used to accommodate the redundant coding bits? (5 points)

(f) If raised cosine pulses with roll-off $r = 0.3$ are used for the link, what is the *uncoded* bandwidth of the transmitted digital system? (5 points)

(g) Based on your answer in (f), what fraction of Shannon Channel capacity is used in this particular link? (10 points)

(h) Draw the signal constellation for this link design. (5 points)

(i) Now let us add the ability of this handset to spread the transmitted signal for code division multiple access (CDMA). If there are 20 equal-powered handset users sharing the spectrum with CDMA, what should the processing gain M be to achieve a BER of 10^{-4} on an *uncoded* link. (10 points)

(j) Design and sketch a possible m-sequence block diagram that might output a chipping sequence satisfying the condition in the previous question. You do not have to verify that any feedback taps on shift registers are optimal – just sketch a possible solution. (6 points)

(k) Besides the ability to multiplex users, list 2 other benefits of spread spectrum. (4 points)

(l) Explain why the first stage of the satellite receiver is a band-pass filter instead of an amplifier. (5 points)

(m) How much bandwidth would be required to send this signal with analog double side-band modulation? (5 points)

Cheat Sheet

$$\left(\frac{C}{N}\right)_{\text{despread}} = M\left(\frac{C}{N}\right)_{\text{spread}} \qquad \left(\frac{C}{N}\right)_{\text{spread}} = \frac{C}{P_N + (Q-1)C}$$

Nyquist Rate $f_s = 2f_{\text{max}}$ Uniform Quantization Noise $= 6N\,\text{dB}$

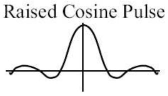
$$\text{Channel Capacity } = B\log_2\left(1 + \frac{C}{N}\right)$$

BER for QPSK $= 2\text{Q}(\sqrt{2\text{SNR}})$ (SNR $\approx C/N$ in this class)

m-sequence with K shift registers: $M = 2^K - 1$

$$Q(x) \approx \frac{1}{x\sqrt{2\pi}}\exp\left(-\frac{x^2}{2}\right) \text{ for } x > 3$$

Raised Cosine Pulse



$$\frac{2f_0\text{sn}(2f_0t)\cos(2\pi\kappa f_0t)}{1-(4\kappa f_0t)^2}$$