Name: ______________________

GTID: ______________________

ECE 6390: Satellite Communications and Navigation Systems
TEST 2 (Fall 2004)

- 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 (20 points)**

(a) ________________

For a satellite that uses [*Answer*] multiple access, the average power of multiple signals must be backed-off from the peak amplifier output to avoid non-linear operation.

(b) ________________

(True or False) If you double the C/N at the receiver, you will double the Shannon channel capacity.

(c) ________________ (1) ________________ (2) ________________ (3)

Name three types of error correction codes.

(d) ________________

A [*Answer*] filter is the optimal method for detecting a digital symbol.

(e) ________________

Rayleigh fading is a special case of Rician fading when K = [*Answer*].

(f) ________________

A digital signal has a symbol period of 100 ns. Each symbol is used on in-phase and quadrature channels to code 32 discrete states. If the real data rate is 25 Mbits/sec, then [*Answer*] percent of the signal bits represent redundant error-correction coding.

(g) ________________

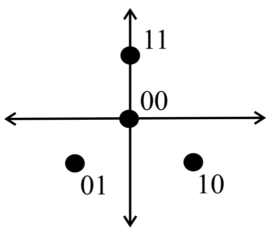
(True or False) TDMA is best-suited for analog signals.

(h) Check the boxes below for scenarios that do *not* lead to Rician fading in a radio link.

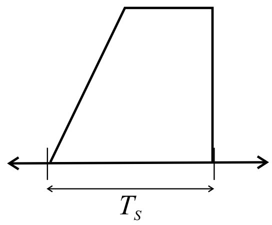
- ☐ A satellite mobile phone moves through an environment filled with nearby scatterers.
- ☐ The output amplifier of a bent-pipe transponder operates in saturation (nonlinear input-output relation).
- ☐ Another TDMA packet collides with the data packet that an ES was trying to send.
- ☐ A 30 GHz ES points towards a GEO satellite during a storm.

2. **Digital Transmissions:** A digital alien signal is received from outer space which uses the following (bizarre) signal constellation and symbol shape.

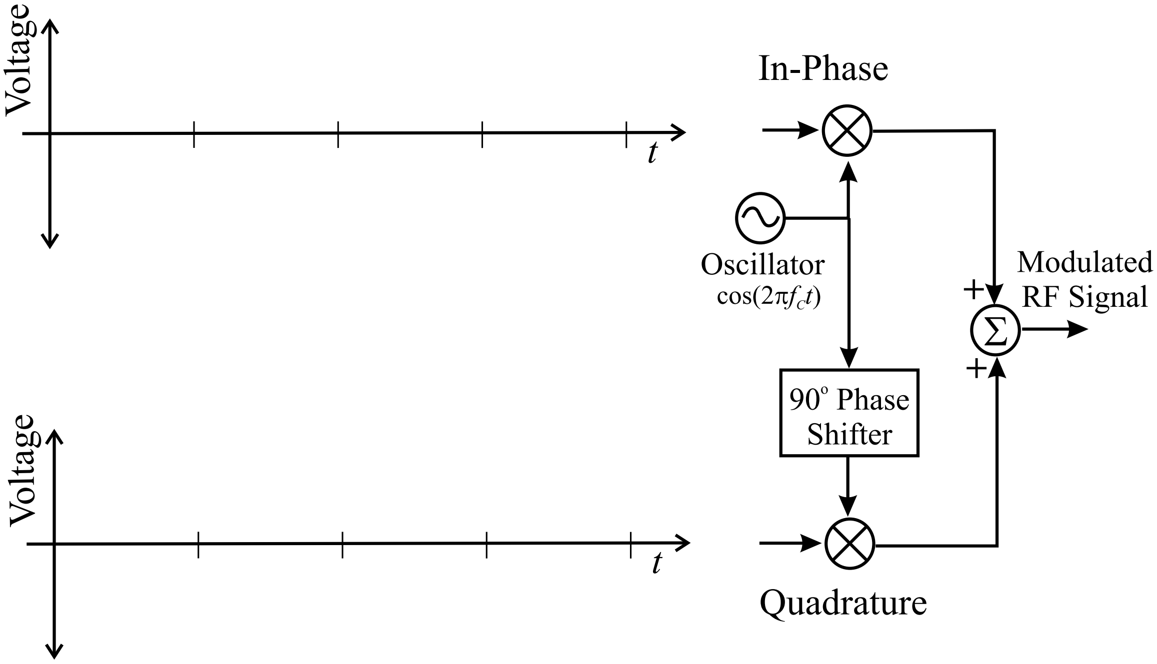
Signal Constellation



Symbol Shape



(a) In the two graphs below, make a rough sketch of the in-phase and quadrature signals that would be sent into the alien's IQ-modulator for the following data sequence: **10000111** **(16 points)**



(b) What might be one of the drawbacks in using a symbol with this type of pulse shape? **(9 points)**

3. **Video Over Satellite:** A 14 GHz geostationary satellite is used to transmit a video signal to earth using one of three proposed methods. Assume a link distance of 36,000 km and an earth station that operates with 50 K of system noise temperature.

- *Method A:* An analog video signal will be sent using VSB-AM with total bandwidth of 6 MHz. Signal fidelity requirements demand a carrier-to-noise ratio of at least 40 dB.

- *Method B:* The same analog video signal in Method A will be sent with FM, occupying a final RF bandwidth of 30 MHz. Assume a pre-emphasis/de-emphasis gain of 7 dB.

- *Method C:* The video signal will be digitized, compressed, and sent using the MPEG-2 protocol, which operates at an average data rate of 28.2 Mbits/sec. This digital transmission will occupy a total RF bandwidth of 43.2 MHz and will employ the World's Greatest Possible Error Correction Code (WGPECC).

Answer the following questions based on this scenario.

(a) How much more/less transmit power in dB is required for Method B to maintain the same effective C/N as Method A? (Do not include the subjective gain factor Q in this calculation.) **(15 points)**

(b) How much more/less transmit power in dB is required for Method C compared to Method A for maintaining the digital link? **(15 points)**

(c) If the maximum tolerable BER is 10^{-5} for Method C, how much coding gain did WG-PEECG provide the link when compared to an uncoded QPSK signal? (use Q-function graph on last page to assist your calculation) **(10 points)**

(d) If you were told that Method C uses BPSK for its digital modulation with a raised cosine pulse, what would the roll-off factor be? **(5 points)**

(e) Other than transmit power, what are some of the engineering trade-offs in choosing one of the 3 methods? **(10 points)**

Cheat Sheet

$$\lambda f = c \qquad c = 3 \times 10^8 \text{ m/s}$$

$$P_R = P_T + G_T + G_R - 20\log_{10}\left(\frac{4\pi}{\lambda}\right) - 20\log_{10}(r) - \text{Additional Loss in dB}$$

$$P_N = kTB \qquad k = 1.3807 \times 10^{-23} \text{ J K}^{-1}$$

$$\text{FM SNR (in dB)} = \left(\frac{C}{N}\right)_{\text{dB}} + 10\log_{10}\left(\frac{B_{\text{RF}}}{f_{\max}}\right) + 20\log_{10}\left(\frac{f_{\text{peak}}}{f_{\max}}\right) + 1.8 + P$$

$$B_{\text{FM}} = 2(f_{\max} + f_{\text{peak}}) \qquad \text{Channel Capacity } = B\log_2\left(1 + \frac{C}{N}\right)$$

$$\text{BER for QPSK:} = Q\left(\sqrt{2\frac{C}{N}}\right) \qquad \text{Raised Cosine BW} = (1+r)R_b$$