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ECE 6390: Satellite Communications and Navigation Systems
TEST 2 (Fall 2007)

- 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 80 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: _____

X

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.

Short Answer Section (2 points/blank)

1. horizontal

Rain attenuation is strongest for Answer polarization.

2. envelope detector (1) cheap (2)

Lucille Ball's braces act like a(n) Answer 1, which is a very cheap/expensive (2) type of receiver in commercial radio practice.

3. false

True or False: It is possible to use SSB and QAM to multiplex 4 signals into the same overlapping bandwidth.

4. SSB

The most bandwidth-efficient form of amplitude modulation is Answer.

5. bits/symbol

Using a more complicated signal constellation trades-off higher Answer for increased bit-error rate.

6. SNR (1) QPSK (2)

Due to low Answer 1, deep space satellites send data mostly using Answer 2 digital modulation.

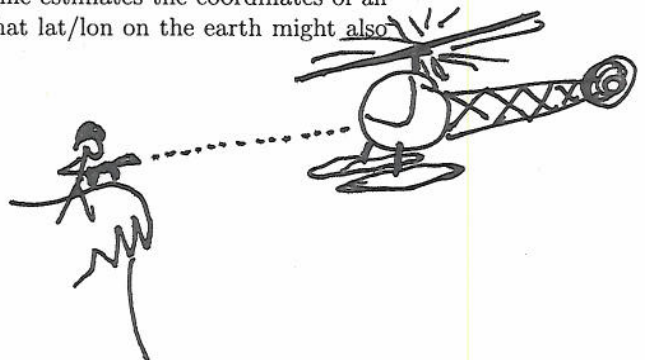
7. d (highest) c b e a (lowest)

Rank the following scenarios in terms of in terms of highest to lowest possible Doppler shift in (Hz):

- (a) geostationary satellite to an Earth station dish in Atlanta at 12 GHz
- (b) 900 MHz cell-phone on a bus traveling 65 m.p.h. on the highway
- (c) SARSAT satellite receiving an EPIRB signal
- (d) NASA space probe orbiting Neptune close to the atmospheric layer, communicating back to Earth at 16 GHz
- (e) 2.45 GHz WiMax link to a pedestrian wireless PDA user

8. 25.70° lat 89.70° lon

A SARSAT satellite riding down the 85.70° W longitude line estimates the coordinates of an EPIRB to be at 25.70° latitude and 89.70° longitude. What lat/lon on the earth might also result in an ambiguous location estimate for the EPIRB?



9. a c f d

If carrier frequency on an existing satellite link increases, which of the following 4 elements in the link will *always* increase:

- (a) dish antenna gain
- (b) LNA gain
- (c) rain attenuation
- (d) free space path loss
- (e) noise bandwidth
- (f) Doppler shift
- (g) FM processing gain
- (h) tropospheric delay

10. Carson's Rule

Answer is the empirical relationship between FM bandwidth and the baseband properties of the signal to be modulated.

11. Faraday Rotation

The magnetic field of the Earth in conjunction with the charged particles of the ionosphere work together to cause Answer in a satellite link.

12. sinc (1) Nyquist (2) bandwidth (3)

In an ideal world, the Answer 1 pulse would be the best digital symbol, because it satisfies the Answer 2 interference criterion with the minimum Answer 3.

13. c (lowest) a b (highest)

Rank the following based on which location would result in the lowest received C/N for a radio Comlink:

- (a) the ice world of Hoth $\sim 250K$ + far from a sun
- (b) a small asteroid in deep space $\sim 3K$ + deep space
- (c) the swamp world of Degobah $\sim 300K$ + close to a sun

14. roll-off (1) bandwidth (2)

Using a higher Answer 1 factor increases the Answer 2 but allows truncated pulses to fit within a tighter out-of-band spectral constraint.

15. true

True or False: Cloud cover can be a factor in a satellite communication link.

16. non-linear/saturated

When out-of-band harmonics appear in a receiver RF chain, this may be a sign of Answer amplifier effects.

17. LNA

The most critical component in an RF chain for reducing system noise is the Answer.

18. modulation (1) SNR (2)

A higher Answer 1 factor in FM results in higher Answer 2 at the output of a receiver – at the expense of larger occupied RF bandwidth.

19. in-phase (1) quadrature (2)

The Answer 1 and Answer 2 channels are 90° out-of-phase with one another.

20. Cassegrain (1) Gregorian (2)

Name 2 types of dish antenna geometries that use sub-reflectors.

21. quantization

Uniform Answer introduces $6N$ dB of signal-to-noise ratio to an otherwise perfect signal.

22. 10 Msamples/sec aliasing (2)

An analog television signal with 5 MHz of baseband bandwidth must be sampled by at least Answer 1 to avoid Answer 2.

Proof:
① Professors require time and money:
Professors = time × money
② Time is money ∴ Professors = money²
time = money ∴ Professors = money²
③ Money is the root of evil
money = $\sqrt{\text{evil}}$ ∴ Professors = $(\sqrt{\text{evil}})^2$
④ Thus, Professors are evil
Professors = evil

23. A pair of signals is analog-modulated using the following format:

$$x_p(t) = A \cos \left(2\pi f_c t + 2\pi k_m \int_0^t [x_1(t) \cos(2\pi f_o t) + x_2(t) \sin(2\pi f_o t)] dt \right)$$

Using block diagrams, sketch the complete structure of a receiver that would demodulate and separate these 2 signals. The components available to you are: band-pass filters, low-pass filters, high-pass filters, capacitors and diodes, antennas, LNA, mixers, oscillators, phase-shifters, and differentiators. You may assume ideal oscillators. Label the outputs clearly. (18 points)

