##### ECOMMS Midterm Exam March 22, 2010

#### Spring 2010 1:40 – 3:40 PM

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**Student’s Name**: \_\_\_\_\_\_\_\_\_\_\_\_

**DIRECTIONS**: This exam consists of **three** parts – Part A, Part B and Part C. Answer **all** questions in all **three** parts. This exam is **OPEN TEXTBOOK/NOTES, CLOSED COMPUTER/WEB**. Calculators are permitted. Remember to specify UNITS for all answers. Use proper NOTATION. Show ALL WORK.

**Part A** (8 questions @ 5 points each = 40 points)

1. An HDTV has 1,080 scan lines and 1,920 pixels per line. If each pixel is quantized with TrueColor 24-bit resolution (8-bits each for Red, Green and Blue respectively), what is the total information contained in each frame? You can assume that each pixel can assume any shade of color with equal probability.
2. Write down the *frequency*-domain expressions for the following *time*-domain signals:
3. Write down the *time*-domain expressions for the following *frequency-*domain signals:
4. What are the conditions under which the FFT of a signal is an accurate representation of its *Continuous Fourier Transform*?

1. You are given a pure sinusoid, *s*(*t*) = 10 cos(21000*t*) and a zero-mean, unit variance, Gaussian noise signal *n*(*t*) = *N*(0,1). How would you generate a noise signal *n*1(*t*) that can be added to *s*(t) to obtain a noisy signal *s*1(*t*) = *s*(*t*) + *n*1(*t*), such that the SNR of *s*1(*t*) is –3 dB?
2. What is the *Nyquist* sampling criterion? Illustrate with sketches, what happens when a signal bandlimited to ±*B* Hz is sampled:
   1. At or above the *Nyquist* frequency;
   2. Below the *Nyquist* frequency.

1. What are the advantages and disadvantages of *standard* AM transmission? Discuss the tradeoffs associated with making improvements to *standard* AM transmission, in order to minimize its disadvantages.
2. Are you interested in going to grad school? Why, or why not?

**Part B**

1. A commercial broadcast receiver not only has the task of demodulating the incoming RF signal, but must also be able to selectively tune to the carrier frequency and separate the desired signal from other modulated signals that may be picked-up along the way.

The *superheterodyne* receiver performs these functions in an elegant and practical way – specifically, it overcomes the difficulty of having to build a tunable and highly selective and variable filter.

A two-stage coherent detection technique is used. In the first stage, the RF signal is shifted *down* to an *intermediate frequency* (IF) by multiplying it with a local oscillator frequency that is *greater* than the incoming carrier. In the second stage, the signal in the IF range is processed through a second coherent detector to bring it down to the baseband.

Consider a standard-AM signal at a station frequency of 800-kHz, single-tone modulation at 80% depth, that is detected by a superheterodyne receiver with an IF of 455-kHz.

* 1. Draw a block diagram of the 2-stage superheterodyne receiver system described above.
  2. Perform a time- and spectral-domain analysis as the incoming RF signal is converted to IF and then to baseband. In your analysis at each stage of the block diagram, you should provide equations describing the signals in the time- and frequency- domains. Also provide sketches of the signal spectrum at each stage, *clearly indicating all amplitudes and frequencies*.

(20 points)

**Part C**

1. *Avatar – The Prequel*

It’s the year 2060, and the *Avatar* franchise has already released the following series of movies: *The Return of the Avatars*, *Avatars Reloaded*, and *Avatar – The Final Frontier*. James Cameron III, the son of the original movie’s director has decided it is time to exploit this profitable franchise one more time by making *Avatar – The Prequel*.

In 2060, movies are released direct to 3-D immersive visualization systems integrated into people’s homes. Families view movies holographically projected in 3-D into their living/media rooms.

You are hired as an intern by the Chief Engineer responsible for the technical production of the movie – Dr. Lucy Kowalski (grand-daughter of Nick Kowalski – Rowan ECE graduating class of 2016). She has assigned the specific task of designing the studio-to-home communications system to you, beginning with the calculations of the following system specifications:

* 1. What is the minimum size [Bytes, kB, MB….] of the memory buffer required to store the information required to display a single frame in a scene consisting of 1 – 5 *Avatars* at a time? Note that only the colored, pixellated surface of each *Avatar* needs to be displayed.
  2. What is the required data transfer rate for streaming the movie scenes to ensure a realistic visualization? Note that this will be depended on the frame rate required for persistence of vision (typically 30 frames/sec).
  3. What is the channel bandwidth required to stream the 3-D immersive movie?
  4. What size memory buffer will you design for streaming the entire movie of length 1-hr (people’s attention spans have diminished by 2060).
  5. How will the problem specifications change if instead of the movie, the associated video-game is being played (this will require user interactivity with the *Avatars*).

Make other justifiable assumptions as necessary. Show all work – you will be graded on the technical merits of your argument and your demonstrated skill in applying ECOMMS design equations for arriving at the required project specifications.

(40 points)