##### ECOMMS Midterm Exam March 28, 2011

#### Spring 2011 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. Compute the minimum bandwidth required for a 720p HDTV (1280×720 pixels, 24-bits color resolution per pixel) operating at an SNR of 24-dB.
2. What are the characteristics of a practical communications system that make it different from an ideal communications system?
3. Illustrate, with sketches and equations, the *duality* property of the continuous Fourier transform.
4. An ideal bandpass filter has its passband in the range of 10-kHz – 20-kHz. Describe this filter in the time- and frequency-domains with appropriate sketches.
5. Illustrate, with sketches and equations, the use of a sinusoidal carrier/local oscillator to achieve product modulation and coherent detection of an arbitrary message signal.
6. How is FM a superior method of modulation than AM?
7. What are your career/continuing education plans after graduation?
8. A DSB-SC transmitter operates at 800-kHz carrier frequency with an unmodulated carrier power of 5-kW. What is the carrier signal amplitude? If the carrier is modulated by a single-tone message of amplitude 0.9-V, compute the total power in the modulated signal.

**Part B**

1. Perform a spectral-domain analysis of the system shown in Figure 9. In your analysis at each stage of the block diagram, you should provide equations describing the signals in the frequency domain. Also provide sketches of the signal spectrum at each stage, *clearly indicating all amplitudes and frequencies*.

GND

*m*(*t*): sinusoidal message;

Amplitude = 1 V

Frequency = 5 kHz

+

-

**S**: Switch;

Closed only for

1 ms

**Band Pass Filter**

3 – 7 kHz

**Amplitude**

**Modulator**

+

-

*c*(*t*): sinusoidal carrier;

Amplitude = 10 V

Frequency = 800 kHz

*s*(*t*): AM signal

*ms*(*t*)

*mf*(*t*)

**Figure 9:** Modulation system.

(20 points)

**Part C**

1. *Remote Monitoring of Radiation Leak at the Fukushima Daiichi Nuclear Plant*

Following the devastating March 11 earthquake and tsunami that engulfed the northeast coast of Honshu in Japan, a loss of electric power has led to a possible meltdown at the Fukushima Daiichi Nuclear Station that is operated by the Tokyo Electric Power Company (TEPCO).

You have been hired by the Government of Japan and TEPCO to design a system for remotely monitoring the radiation at source (near the core) of the nuclear plant. The instrument which will measure the radiation is a *Geiger-Müller* counter that will be airlifted (along with the associated communications circuits that you will design) and dropped into the vicinity of the core. The counter generates a DC voltage corresponding to counts per minute (CPM) or per second (CPS) that must be made available remotely for assessing the radiation leakage at the core. The counter that you are provided has the following resolution and range: 1-CPM to 5,000-CPS.

Other information that you may choose to arrive at your design:

* The *Geiger-Müller* counter is calibrated to Cesium137.
* 120 CPM on the meter (for Cs137) corresponds to radiation absorption of 1 Sv/hr (microSieverts per hour).
* **Average annual human exposure to radiation (U.S.)**6 milliSievert (mSv)
* **Radiation dose for increase cancer risk of 1 in a 1,000**12.5 milliSievert (mSv)
* **Earliest onset of radiation sickness**750 milliSievert (mSv)
* **Onset of radiation poisoning**3,000 milliSievert (mSv)
* **Expected 50% death from radiation**  
  4,000 milliSievert (mSv)

Design a communications system for this application. Your design should address the following points (and is not limited to only these):

1. Your assumptions, clearly stated, for addressing the problem.
2. The overall block-diagram of your system-level design.
3. The protocols/methods that you will use for acquiring baseband signals from the *Geiger-Müller* counter, translating into bandpass for communications to a remote station, and recovering the baseband signal for analysis at the remote location.
4. Circuit/chip details (if available) of the sub-systems that comprise each block in your system diagram including any numerical calculations that will demonstrate the rigor of your design.

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

(40 points)