CARLETON UNIVERSITY

Department of Systems and Computer Engineering

SYSC4700 Telecommunications Engineering Winter 2015

Term Exam – 11 February 2015

Duration: 75 minutes

Instructions:

1. **NO CELL PHONES. Closed-book exam (no aid-sheet).**
2. **Write answers in the spaces provided on the question sheet.**
3. **If necessary, use both sides of a page.**

Name:

Student Number:

Question	Mark	Max possible mark
1		80
2		65
3		45
Total		190

Question 1 – Short Questions on Transmission and Link Budget [80 points]

a) [5 pts] If it takes 1 minute to download a movie using wired internet, how long will it take to download the same movie using wireless internet where the transmission speed is one-tenth of the wired speed?

b) [5 pts] What is the wavelength if the carrier frequency is 1 GHz.

c) [10 pts] What is the highest bit-rate achievable in a system if

- SNR = 20 dB
- Number of transmit antennas = 6
- Number of receive antennas = 4
- Bandwidth = 20 MHz

d) [15 pts] The PSD (power spectral density), $S_X(f)$, of a signal $X(t)$ is given as

$$S_X(f) = \begin{cases} \beta, & -950MHz \le f \le -900MHz \\ \beta, & 900MHz \le f \le 950MHz \\ 0, & elsewhere \end{cases}.$$

- Find the bandwidth of $X(t)$.
- Find the total power of $X(t)$.

e) [20 pts] The average path-loss in a wireless link is modeled as $PL = \left(\frac{4\pi}{\lambda}\right)^2 d^{3.3}$. When the carrier frequency is 900 MHz, it is observed that *PL*=70 dB while the user is at a particular location. If the carrier frequency is increased from 900 MHz to 45 GHz, what will *PL* be at that same location?

f) [15 pts] In a wireless system, when the path-loss is measured as 70 dB, the corresponding spectral efficiency is calculated as 2.7 bits/sec/Hz according to Shannon's channel capacity formula. Find the spectral efficiency when the path-loss is 80 dB.

g) [10 pts] Sketch the power spectral density (PSD) of white noise.

Question 2 – Short Questions [65 points]

a) **[10 pts]** The term “open” has different meanings when used in the expressions “open standard” and “open source”. Explain.

b) **[15 pts]** Standards: One versus many.

- When is it better to have one standard?

- When is it inevitable to have multiple standards?

c) **[10 pts]** Who invented telephone, in which century?

- Inventor:
- Century:

d) **[10 pts]** What do the following acronyms stand for?

- 3G:
- ITU:
- MIMO:
- FTTH:
- PON:

e) **[20 pts]** State two advantages of packet switching over circuit switching:

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State two disadvantages of packet switching over circuit switching:

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Question 3 [45 marks] – ADC and TDM

a) [10 pts] What are the three main steps in pulse code modulation (PCM)?

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Consider a PCM-based analog-to-digital converter (ADC) for voice signals with the following specifications:

- The ADC captures the detail in the voice signal up to 20 kHz.
- 1024 levels are used for quantization.

Next, consider a time-division multiplexing scheme (TDM) which combines the digital output from users whose analog data is digitized through the above described ADC scheme. A TDM frame consists of samples from 20 users plus N bits for synchronization purposes. The line speed that carries this TDM traffic is 8.2 Mbits/sec and the available bandwidth for transmission is 2.05 MHz.

b) [10 pts] Find the spectral efficiency. If M-QAM is used as the modulation technique, suggest an appropriate M value (substantiate your suggestion).

c) [25 pts] Find the maximum number of synchronization bits (N) that can be used in this TDM scheme.