

ELEX 7860 : Wireless System Design  
2021 Winter Term

**Final Exam**  
**13:00 – 16:20**  
**Friday, April 23, 2021**

This exam has nine (9) questions on nine (9) pages. The marks for each question are as indicated. There are a total of twenty-four (24) marks.

Download this exam and write your answers in the space provided or on a separate sheet of paper. You may print the exam and write the answers by hand, mark up this document using a tablet, or edit the file with a word processor.

You may access books, notes or electronic documents created before this exam. You may not communicate in any other way during the exam.

Please sign the following declaration to confirm your understanding of this:

*This work is solely my own effort and I understand the consequences of plagiarism and other offences described in [BCIT Policy 5104](#).*

Signed: \_\_\_\_\_

Answer all questions. *Show your work*. Draw a box around your final answer. Numerical answers must include units.

When you are done, export your document to a **PDF** file. Submit the PDF file to the Final Exam Assignment folder on the course web site before the submission deadline, 16:00 (4 PM). If you submit multiple times only the most recent submission will be marked.

You may opt to substitute the average mark for Questions 1–3 for the Quiz 1 mark, the average for questions 4–6 for the Quiz 2 mark and the average for questions 7–9 for the Quiz 3 mark.

**Only PDF files will be marked.**

Name: \_\_\_\_\_

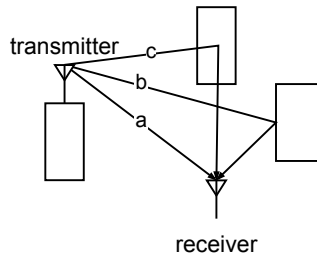
BCIT ID: \_\_\_\_\_

Question	Mark	Max.
1		3
2		5
3		5
4		2
5		2
6		2
7		3
8		1
9		1
Total		24

**Question 1****3 marks**

A fading signal with a Rayleigh distribution has a field strength greater than  $100 \mu V_{\text{rms}}$  10% of the time. What is the mean field strength in  $\mu V_{\text{rms}}$ ?

- (a) A signal transmitted from a base station arrives at a mobile via the three paths shown below: (a) a direct path of length 400 m, (b) a signal reflected back from a building behind the receiver with total path length 700 m at a level of -6 dB relative to the direct path, and (c) a signal reflected from an adjacent building with a total path length of 1 km and a level of -10 dB relative to the direct path. What is the (RMS) delay spread?



- (b) A wireless communication system operating over the channel above uses OFDM with a guard time of  $1 \mu\text{s}$ . Will this system's performance over this channel be degraded in any way by ISI? Briefly explain why or why not.

### Question 3

5 marks

- (a) A wireless communication system uses satellites that orbit at an altitude of 500 km and operate at a frequency of 12 GHz. What is the path loss, in dB, between a ground station and the satellite when the satellite is directly overhead?
- (b) Assuming this system uses circular antennas with a 50 cm diameter and that the effective area of the antenna is equal to its physical area, what is the gain of the antenna in dB?
- (c) If the uplink transmit power is 1 W and both transmit *and* receive antennas have the gain calculated above, what power is received at the satellite? Give your answer in dBm.

#### Question 4

2 marks

A diversity receiver uses maximal-ratio combining and three antennas. The SNRs received on the three antennas are 10 dB, 6 dB and 0 dB.

1. What weights are applied to the signals from the three antennas? Give your answer in linear (voltage gain) units with the largest gain normalized to 1.
2. What is the SNR after diversity combining? Give your answer in dB.

**Question 5****2 marks**

A communication system transmits bits (0 or 1) with a probability of error equal to  $10^{-2}$ . The error rate is the same for 0's and 1's. You will be adding FEC coding to ensure a negligible (arbitrarily small) BER. What is the highest code rate you would ever expect to be able to achieve? Show your work.

- (a) What is the generator matrix for a *systematic*<sup>1</sup> (4,2) repetition code?
- (b) What is the corresponding parity check matrix?

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<sup>1</sup>The data bits are transmitted at the beginning of a codeword.



### Question 7

3 marks

The third-order intermodulation products at the output of a receiver must be 30 dB below the desired output. The desired (in-channel) output level is 1 V<sub>rms</sub> at an impedance level of 50 ohms (Hint:  $P = V^2/R$ ).

- (a) What is the minimum required output IP3 of the receiver in dBm?
- (b) If the receiver has 80 dB of gain from the input to the output, what is the input IP3 of the receiver?

**Question 8****1 marks**

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Which type of spread-spectrum system, DSSS or FHSS, would be able to avoid interference to nearby narrow-band users of overlapping spectrum? Explain briefly.

**Question 9****1 marks**

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By how much could a MIMO system increase throughput to one user if the transmitter had four antennas and the receiver had three?