

ELEX 7860 : Wireless System Design  
2024 Winter Term

**Final Exam**  
**14:30 – 17:30**  
**Friday, April 19, 2024**  
**SW01-3150**

This exam has twelve (12) questions on three (3) pages. The marks for each question are as indicated. There are a total of twenty-eight (28) marks. Answer all questions. Write your answers and all rough work in this paper and nowhere else. Show your work. Underline or draw a box around your final answer. Numerical answers must include units. Books and notes are allowed. No electronic devices other than calculators are allowed. **Show your work.**

This exam paper is for:

**Paper, Test 1** A00123456

Each exam is equally difficult.

Answer your own exam.

Do not start until you are told.

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

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

Signature: \_\_\_\_\_

### Question 1

2 marks

A signal with a Rayleigh-distributed amplitude has a *median* amplitude of 1 mV. Assuming a  $50\ \Omega$  impedance, what is the signal's RMS power? Give your answer in dBm. *Hint: The cumulative distribution function (CDF) of the amplitude is 50% at the median amplitude.*

### Question 2

3 marks

A TV transmitter on Mount Seymour broadcasts 90 kW at a frequency of 600 MHz. The transmit antenna has a gain of 6 dBi and you can assume a receive antenna gain of 0 dBi. If the received signal power must be at least  $-40$  dBm, what is the maximum distance at which the TV signal can be received? Give your answer in km.

### Question 3

3 marks

You're driving down the highway listening to an FM broadcast station transmitting at 100 MHz and notice the signal fading six times per second. Assuming Clarke's model applies and the signal is faded when the signal level is 10 dB below the (RMS) mean level, how fast are you driving? Give your answer in km/h.

### Question 4

2 marks

A signal is received over two paths whose lengths differ by 300 m. The power received along the longer path is half of that on the shorter path. What is the (RMS) delay spread? Give your answer in microseconds.

### Question 5

3 marks

In a NLOS environment you measure an average signal level of  $-40$  dBm at a distance of 10 m and  $-80$  dBm at a distance of 100 m. Assuming a power law path loss model applies, what would you estimate to be the average signal level at a distance of 20 m?

### Question 6

2 marks

A wireless receiver uses maximal-ratio combining diversity on four branches. Two of the branches have an SNR of 10 dB and two have an SNR of 16 dB. What is the SNR after combining? Give your answer in dB.

### Question 7

3 marks

A MIMO system uses 4 transmit and 4 receive antennas. The channel matrix has four equal, non-zero eigenvalues. The signals are received with an SNR of 13 dB, the noise is Gaussian and the bandwidth is 12 MHz. What is the (Shannon) capacity of the system? Give your answer in Mbps.

### Question 8

2 marks

- (a) What is a generator matrix for a systematic (6,2) repetition code? The parity bits may be transmitted in any order. Follow the conventions used in the lecture notes.
- (b) What is the corresponding parity check matrix?

### Question 9

2 marks

A communication system is transmitting at 16 Mb/s, including parity bits, using a rate 3/4 code over a bandwidth of 12 MHz. The SNR is 10 dB. What is  $E_b/N_0$ ? Give your answer in dB.

### Question 10

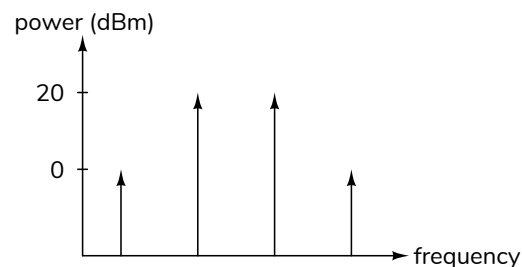
2 marks

An OFDM system is being designed to cope with multipath propagation in an environment where the maximum path length differences are expected to be 60 m. The sample rate is 50 MHz. What minimum duration of cyclic prefix should be used? Give your answer in number of samples.

### Question 11

2 marks

You measure the following spectrum at the output of an RF amplifier for a two-tone input. Assuming the amplifier is operating in its linear region, what is the amplifier's OIP3? Give your answer in dBm.



## Question 12

2 marks

The input of an RF amplifier is connected to a calibrated noise source that outputs broadband noise with a power spectral density of  $-164$  dBm/Hz when it is turned on.

- (a) What is the ENR of the noise source? Give your answer in dB.
- (b) When the noise source is turned on, the power spectral density of the noise at the output of the amplifier increases by 7 dB. What is the amplifier's noise figure? Give your answer in dB.