ELEX 7860 : Wireless System Design
2022 Winter Term

Final Exam
14:30 – 17:20
Friday, April 22, 2022
SW03-1750

This exam has twelve (12) questions on three (3) pages. The marks for each question are as indicated. There are a total of twenty-six (26) marks. Answer all questions. Write your answers and all rough work in this paper and nowhere else. Show your work. 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 to do so.

Name: _____

BCIT ID: _____

Signature: _____

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Question 1 — 2 marks

Assuming the same transmit and receive antennas are used, what antenna gains would be required to achieve a received signal level of −80 dBm over a 10 km LOS path at a frequency of 2.4 GHz if the transmit power is 20 dBm? Give your answer in dBi.

Question 2 — 2 marks

You observe a pseudo-random bit pattern that you believe is from a ML PRBS generator. The longest sequence of consecutive 1's is 24 bits long. What would you expect to be the period of the sequence? Give your answer in bits.

Question 3 — 2 marks

A signal with a Rayleigh-distributed amplitude is received along with constant-power additive noise. You require that the signal be faded less than 1% of the time. A fade is defined as an SNR of less than 10 dB. What average SNR is required? *Hint: Since the noise level is constant, the SNR is proportional to the signal power.*

Question 4 — 2 marks

A signal is received by a moving receiver over a NLOS channel and the directions of arrival are uniformly distributed as in Clarke's model. The signal is faded 10% of the time. You measure an average of 10 fades per second. What is the average fade duration?

Question 5 — 3 marks

You set up a test transmitter in a warehouse and make some measurements of the received signal strength. The mean received signal level at a distance of 10 m is −40 dBm. The path loss exponent appears to be 3.5. The standard deviation of the path loss (due to shadow fading) appears to be 9 dB. You need to achieve a signal level of more than −80 dBm at distances of up to 100 m with 95% probability.

Assuming a power law is an appropriate model for the mean signal level and a log-normal model is a reasonable model for probability distribution of path loss due to shadowing, by how much do you need to increase (or decrease) the transmit power?

Hint: the probability that normally-distributed random variable has a value 1.65 standard deviations above the mean is about 5%.

Question 6 — 2 marks

A wireless system uses selection diversity. Without diversity the probability of a fade is 20%. How many independently-fading branches would be required to reduce the probability of a fade to less than 1%? Your answer should be an integer.

Question 7 — 2 marks

You need to add FEC to a existing communication system to reduce the error rate to a very low value. You only have access to the binary data at the input and output of the system. The system transmits and receives bits at a rate of 100 kb/s and the BER without FEC is 8×10^{-3}. What is fastest possible rate at which you can hope to transmit information over this channel with an arbitrarily low error rate?

Question 8 — 2 marks

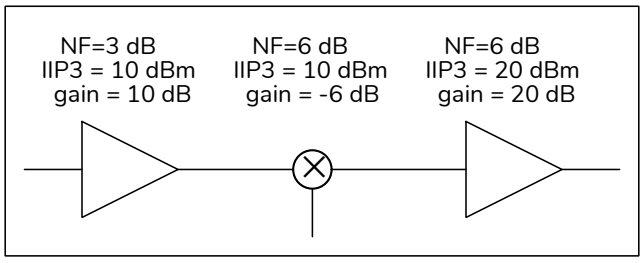
You have decided to use a Reed-Solomon code using symbols from GF(64) in a communication system. From simulations you've determined that you need to correct errors in at least 10% of the symbols. What is the block size in units of symbols? How many parity symbols should you use in each block? Your answers should be integers.

Question 9 — 2 marks

You measure the SNR at the IF of a receiver as 10 dB. The noise bandwidth is 350 kHz. The bit rate is 1 Mb/s. No FEC is used. What is the E_b/N_0? Giver your answer in dB.

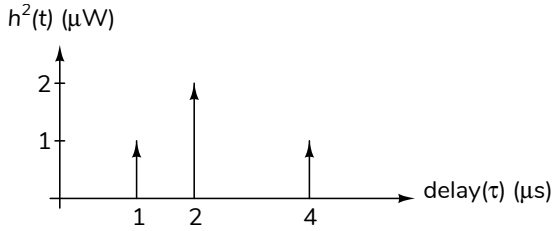
Question 10 — 4 marks

The following diagram shows the front end of a receiver. The input IP3 (IIP3), noise figure (NF) and gain of each stage are as shown. What are the overall (cascade) input IP3 and NF?



Question 11 — 2 marks

You measure the impulse response of a channel to be as shown below:



How would you report the (excess) delay spread of this channel? Give the value and the units.

Question 12 — 1 marks

You are considering using MIMO to improve the data rate of a communication system. You measure the channel matrix using arrays of 5 transmit and 5 receive antennas. You compute the eigenvalues of the channel matrix and find that in most cases this matrix has 3 significant (non-zero) eigenvalues. By how much would you expect to be able to improve the data rate of the system using these antennas? Explain briefly.