

FINAL EXAM
9:30 PM – 12:20 PM
Wednesday, April 17, 2019

This exam has six (6) questions on two (2) 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. 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:

Exam 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: _____

Question	Mark	Max.
1		6
2		4
3		5
4		7
5		3
6		3
Total		28

Question 1**6 marks**

- (a) What is the free-space path loss at a distance of 600 m at a frequency of 3 GHz? Give your answer in dB.
- (b) A wireless communication system operating over this (line-of-sight) channel uses antennas of 9 dB gain for both transmission and reception and a transmit power of 200 mW. What is the received power? Give your answer in dBm.

Question 2**4 marks**

A vehicle travelling at a speed of 30 m/s receives a signal at a frequency of 2 GHz that is experiencing Rayleigh fading. There is no line-of-sight component and the angle of arrival is uniformly distributed over $[0, 2\pi)$.

- (a) How often does the received signal level drop 16 dB below the mean? Give your answer in Hz.
- (b) What is the average duration of each such fade? Give your answer in seconds.

Question 3**5 marks**

An OFDM signal occupies a bandwidth of 3.125 MHz. The sampling rate is 4 MHz. The FFT size is 256.

- (a) Assuming all the subcarriers that are used are contiguous (adjacent to each other), how many of the subcarriers are used?
- (b) If there is a $8 \mu\text{s}$ guard interval (cyclic extension) between OFDM symbols, what are: (i) the OFDM symbol duration and (ii) the OFDM symbol rate? Include the effect of the guard interval. Give your answers in seconds and Hz.
- (c) If four bits are transmitted per (used) subcarrier, what is the overall bit rate (including the effect of the guard interval)? Give your answer in bps.

Question 4**7 marks**

An $(n, k) = (5, 3)$ FEC code has the generator matrix:

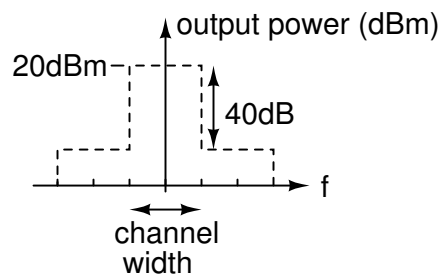
$$G = \begin{bmatrix} 1 & 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 & 0 \end{bmatrix}$$

- (a) What is the corresponding parity check matrix?
- (b) What codeword will be transmitted for the data vector 1, 1, 0?

Question 5

3 marks

The power spectrum at the output of an RF amplifier must fall below the limits in the following diagram:



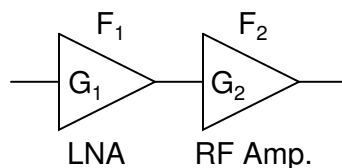
You may assume that the adjacent-channel power is caused solely by third-order intermodulation products. Thus, the power of any intermodulation products falling in the adjacent channel must be 40 dB below the power of the in-channel signals.

The power of the in-channel signals is 20 dBm. What is the minimum output IP3 requirement for the RF amplifier? Give your answer in **Watts**.

Question 6

3 marks

The front-end of a receiver consists of an LNA followed by a second RF amplifier:



The noise figure of the LNA is $F_1 = 2$ dB and that of the RF amplifier $F_2 = 6$ dB. What LNA gain, G_1 , will result in a noise figure of the cascade of 3.5 dB? Give your answer in dB.

This blank page may be used for rough work or to continue an answer. Note this on the appropriate answer page (e.g. write “Answer continued on page 8.”)

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Exam 2 A00123456

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Question	Mark	Max.
1		6
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4		7
5		3
6		3
Total		28

Question 1**6 marks**

- (a) What is the free-space path loss at a distance of 300 m at a frequency of 6 GHz? Give your answer in dB.
- (b) A wireless communication system operating over this (line-of-sight) channel uses antennas of 6 dB gain for both transmission and reception and a transmit power of 100 mW. What is the received power? Give your answer in dBm.

Question 2**4 marks**

A vehicle travelling at a speed of 20 m/s receives a signal at a frequency of 1 GHz that is experiencing Rayleigh fading. There is no line-of-sight component and the angle of arrival is uniformly distributed over $[0, 2\pi)$.

- (a) How often does the received signal level drop 13 dB below the mean? Give your answer in Hz.
- (b) What is the average duration of each such fade? Give your answer in seconds.

Question 3**5 marks**

An OFDM signal occupies a bandwidth of 3.125 MHz. The sampling rate is 4 MHz. The FFT size is 256.

- (a) Assuming all the subcarriers that are used are contiguous (adjacent to each other), how many of the subcarriers are used?
- (b) If there is a $16 \mu\text{s}$ guard interval (cyclic extension) between OFDM symbols, what are: (i) the OFDM symbol duration and (ii) the OFDM symbol rate? Include the effect of the guard interval. Give your answers in seconds and Hz.
- (c) If two bits are transmitted per (used) subcarrier, what is the overall bit rate (including the effect of the guard interval)? Give your answer in bps.

Question 4**7 marks**

An $(n, k) = (5, 3)$ FEC code has the generator matrix:

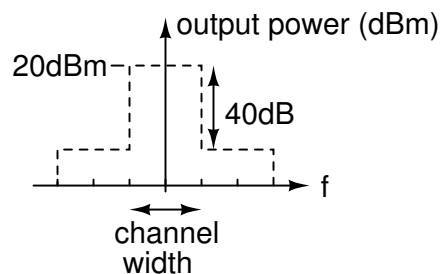
$$G = \begin{bmatrix} 1 & 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 & 1 \\ 0 & 0 & 1 & 1 & 0 \end{bmatrix}$$

- (a) What is the corresponding parity check matrix?
- (b) What codeword will be transmitted for the data vector 1, 1, 0?

Question 5

3 marks

The power spectrum at the output of an RF amplifier must fall below the limits in the following diagram:



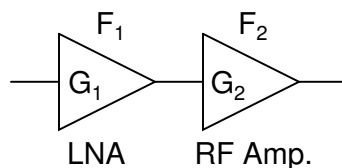
You may assume that the adjacent-channel power is caused solely by third-order intermodulation products. Thus, the power of any intermodulation products falling in the adjacent channel must be 40 dB below the power of the in-channel signals.

The power of the in-channel signals is 20 dBm. What is the minimum output IP3 requirement for the RF amplifier? Give your answer in **Watts**.

Question 6

3 marks

The front-end of a receiver consists of an LNA followed by a second RF amplifier:



The noise figure of the LNA is $F_1 = 2$ dB and that of the RF amplifier $F_2 = 9$ dB. What LNA gain, G_1 , will result in a noise figure of the cascade of 3.5 dB? Give your answer in dB.

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