

ELEX 7860 : Wireless System Design  
2024 Winter Term

Quiz 5

11:30 – 13:20

Friday, March 22, 2024

SW01-2590

This exam has four (4) questions on two (2) pages. The marks for each question are as indicated. There are a total of fifteen (15) 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 to do so.

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

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

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

*Hint: Don't mix up logarithmic and linear units.*

### Question 1

3 marks

The noise at the output of an amplifier is measured with a spectrum analyzer. A calibrated noise source with an ENR of 15 dB is connected to the amplifier input. When the source is turned on, the measured noise level at the output increases by 13 dB. What is the noise figure of the amplifier?

### Question 2

2 marks

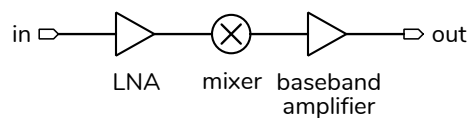
A wireless device can transmit to another wireless device using modulation, coding, and a bandwidth that allows a data rate of 20 Mb/s using one transmit antenna and one receive antenna.

What is the highest data rate that could be achieved using MIMO techniques if there were three transmit antennas and two receive antennas?

### Question 3

4 marks

The diagram below shows a block diagram of a receiver. The LNA has a gain of 10 dB. The mixer has a *loss* of 6 dB. The baseband amplifier has a noise figure of 10 dB and a gain of 60 dB. What LNA noise figure is required to keep the overall noise figure of the receiver to less than 10 dB? Give your answer in dB.

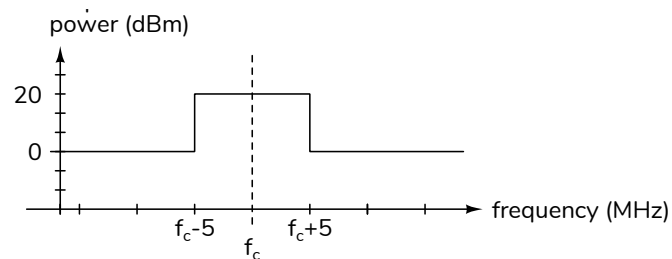


## Question 4

6 marks

- (a) If a signal consisting of two tones (sinusoids) at frequencies  $f_c + 5$  MHz and  $f_c - 5$  MHz were applied to the input of an RF amplifier, what would be the frequencies of the third-order intermodulation products?

- (b) The following “spectral mask” shows the maximum allowable transmit power level at the output of a wireless transmitter at different frequencies relative to the carrier frequency,  $f_c$ . The desired signal contains frequency components between  $f_c - 5$  MHz and  $f_c + 5$  MHz.



Assuming the only significant distortion is due to the final RF amplifier and that the required output power for a two-tone input is 20 dBm, what is the required OIP3 of the final amplifier?

ELEX 7860 : Wireless System Design  
2024 Winter Term

Quiz 5

11:30 – 13:20

Friday, March 22, 2024

SW01-2590

This exam has four (4) questions on two (2) pages. The marks for each question are as indicated. There are a total of fifteen (15) 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 2** A00123456

Each exam is equally difficult.

Answer your own exam.

Do not start until you are told to do so.

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

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

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

*Hint: Don't mix up logarithmic and linear units.*

### Question 1

3 marks

The noise at the output of an amplifier is measured with a spectrum analyzer. A calibrated noise source with an ENR of 15 dB is connected to the amplifier input. When the source is turned on, the measured noise level at the output increases by 13 dB. What is the noise figure of the amplifier?

### Question 2

2 marks

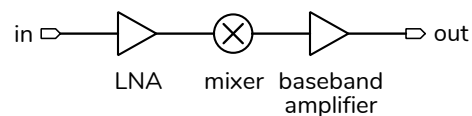
A wireless device can transmit to another wireless device using modulation, coding, and a bandwidth that allows a data rate of 10 Mb/s using one transmit antenna and one receive antenna.

What is the highest data rate that could be achieved using MIMO techniques if there were three transmit antennas and two receive antennas?

### Question 3

4 marks

The diagram below shows a block diagram of a receiver. The LNA has a gain of 10 dB. The mixer has a loss of 6 dB. The baseband amplifier has a noise figure of 10 dB and a gain of 60 dB. What LNA noise figure is required to keep the overall noise figure of the receiver to less than 10 dB? Give your answer in dB.

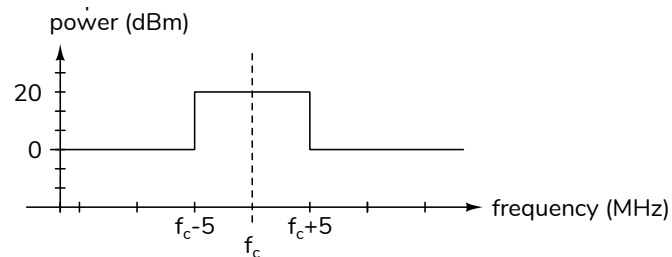


## Question 4

6 marks

- (a) If a signal consisting of two tones (sinusoids) at frequencies  $f_c + 5$  MHz and  $f_c - 5$  MHz were applied to the input of an RF amplifier, what would be the frequencies of the third-order intermodulation products?

- (b) The following “spectral mask” shows the maximum allowable transmit power level at the output of a wireless transmitter at different frequencies relative to the carrier frequency,  $f_c$ . The desired signal contains frequency components between  $f_c - 5$  MHz and  $f_c + 5$  MHz.



Assuming the only significant distortion is due to the final RF amplifier and that the required output power for a two-tone input is 20 dBm, what is the required OIP3 of the final amplifier?