Coláiste na Tríonóide, Baile Átha Cliath
Trinity College Dublin
Ollscoil Átha Cliath | The University of Dublin

Faculty of Engineering, Mathematics and Science

School of Computer Science & Statistics

Integrated Computer Science Programme **Trinity Term 2016**
Year 1 Annual Examinations

Telecommunications 1

Wednesday, 18 May 2016 **Sports Centre** **09:30 – 11:30**

Dr Marco Ruffini

Instructions to Candidates:

You may not start this examination until you are instructed to do so by the Invigilator.

Answer all questions.

The mark assigned is shown at the end of each question.

Answers that do not provide an explanation or show the intermediate steps leading up to the solution will receive zero marks.

Materials permitted for this examination:

Non-programmable calculators are permitted for this examination — please indicate the make and model of your calculator on each answer book used.

1. Describe the following multiplexing techniques showing appropriate diagrams and describe at least one example application for each of the techniques:

   (a) Time Division Multiplexing (TDM). [5 marks]

   (b) Frequency Division Multiplexing (FDM). [5 marks]

   (c) Time Division Duplexing (TDD). [5 marks]

2. You need to transmit the following sequence of bits over a transmission channel: 100111001010.

   (a) Draw a plot of the modulated signal in the time domain when using an 8-ASK digital modulation. 5 marks

   (b) Draw a plot of the modulated signal in the time domain when using a 4-FSK digital modulation. 5 marks

3. You want to digitalise a piece of music previously recorded on tape.

   (a) What is the minimum bit rate of the digitalised signal if you adopt sampling rate and quantisation bit numbers typical of CD recording. 5 marks

   (b) Draw the spectrum of the digitalised signal, when the sampling frequency is reduced to 30 KHz. Then explain what is the problem created by this sampling frequency. 5 marks

   (c) Draw the spectrum of the digitalised signal, when the sampling frequency is 60 KHz. 5 marks

4. A transmission link over copper cable, capable of delivering a symbol rate of 1 Gbaud, is required to achieve a minimum BER of 10^{-3}. The link length is 250 m, the copper cable loss is 0.2 dB/m, the receiver sensitivity is -50 dBm, the power of the transmitter is 0.1 mW, the Signal-to-noise ratio (SNR) at the transmitter is 70dB and the receiver noise figure is 5 dB. Amplifiers have gain of 15 dB and noise figure of 7 dB, while the regenerators have noise figure of 5dB at the receiver, and launch power of 0.1mW and SNR of 70dB at the transmistter. Using the Bit Error Rate (BER) curves in Figure 1, determine:

   (a) What is the maximum transmission rate the system can achieve without any amplifier or regenerator? [7 marks]

   (b) If you can only add one amplifier to the system, with no regenerators, what is the maximum transmission rate the system can achieve ? [8 marks]

   (c) Redesign the system using the minimum number of amplifiers and/or regenerators, indicating their distance relative to the start of the transmission link, to achieve a bit rate of 8Gbit/s with BER of 10^{-6}. [10 marks]

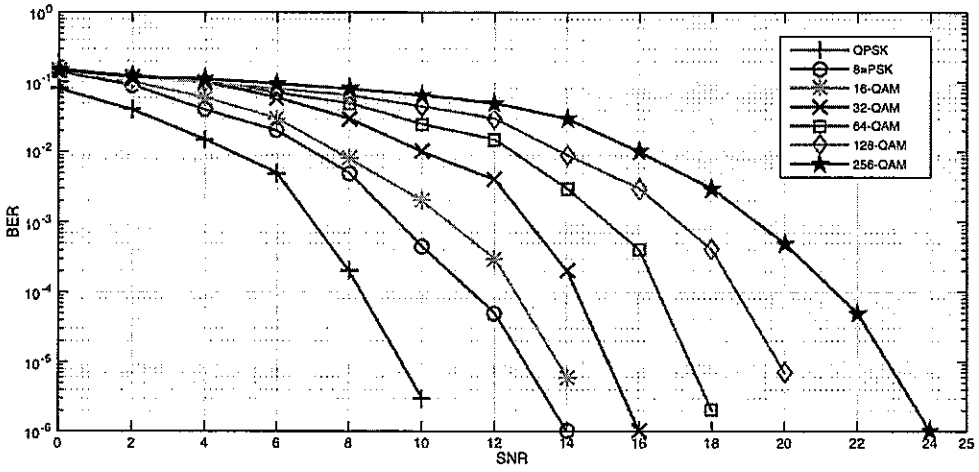

Figure 1: SNR-BER plots for different modulations

5. You need to design the transmission system for a new TV provider that wants to broadcast over the air 10 High Definition (HD-1080p) and 5 Ultra High Definition (UHD-4K) TV channels. HD channels have a resolution of 1920 x 1080 pixels, while UHD channels have a resolution of 3840 x 2160 pixels. Both HD and UHD channels have colour depth of 24 bits and frame rate of 24 frames per second. The compression algorithm used for HD channels achieves a compression factor of 60, while that used for UHD achieves a compression factor of 80.

   (a) Calculate the bit rate required by one HD channel and that required by one UHD channel, both after the compression. [6 marks]

   (b) What modulation should you use if the total bandwidth available for the transmission of all 15 channels together is 85 MHz and you are using Time Division Multiplexing? You can assume the modulation coefficient d to be equal to 0. [9 marks]

6. You need to design a phone transmission system that first digitises and then multiplexes 5 different phone lines into one common cable, using frequency division multiplexing. The digitisation should be carried out using values for sampling rate and quantisation bit numbers that are typical for phone signals, and the digital modulation used should be 2-ASK, with a value for the modulation coefficient d equal to 1.

   (a) What is the bit rate of each digitised phone signal? [3 marks]

   (b) Considering that the minimum frequency to be used in the cable is 50 KHz, what is the maximum frequency of the multiplexed signal, if you use a guard band interval of 10KHz between adjacent signals? [6 marks]

   (c) What are the frequency values of the carriers used to implement the frequency division multiplexing? [6 marks]

7. Draw the constellation diagram for a 16-QAM modulation. [5 marks]