TRINITY COLLEGE DUBLIN
THE UNIVERSITY OF DUBLIN

Faculty of Engineering, Mathematics and Science

School of Computer Science & Statistics

Integrated Computer Science
Year 1 Annual Examination

Trinity Term 2015

CS1031 – Telecommunications I

Tuesday 12th May 2015 **Luce Lower** **9:30 – 11:30**

Dr. Marco Ruffini

Instructions to Candidates

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.

Permitted Materials

Non-programmable calculators are permitted for this examination. Please indicate the make and model of your calculator on the front of your first answer book.

1. You need to design a system for the transmission of 10 *stereo* music channels. The signals to be transmitted have a maximum frequency of 20KHz, and need to be quantized at 20 bits per sample.

   (a) Calculate the total bit rate required by the system if the channels were multiplexed using Time Division Multiplexing (TDM). [3 marks]

   (b) Calculate the total bandwidth required by the system for transmission over a multi-level *baseband* transmission with 16 levels. [3 marks]

   (c) Calculate the total bit rate required by the system if the channels were multiplexed using Frequency Division Multiplexing (FDM), with a 256-QAM modulation, with a value of d=1 and guard intervals of 100KHz. [5 marks]

   (d) What actions could you carry out in order to decrease the bandwidth of the signal without reducing the number of channels, and minimising the impact on the signal quality? [4 marks]

2. (a) Describe the purpose of signal multiplexing, where it is used and its advantages. [3 Marks]

   (b) Describe in detail, showing appropriate diagrams, time division multiplexing. [6 Marks]

   (c) Describe in detail, showing appropriate diagrams, frequency division multiplexing. [6 Marks]

3. Describe the purpose of signal duplexing and use appropriate diagrams to describe the operations of Time Division Duplexing (TDD) and Frequency Division Duplexing (FDD). [10 Marks]

4. You need to design a mobile phone system that uses Time Division Multiplexing (TDM) and is able to support 10 users simultaneously, each operating at a maximum rate of 1Mb/s upstream (e.g., from the user towards the base station) and 10Mb/s downstream. The modulation used is 64-QAM, with a value of d=1. The system uses full-duplex so that the two directions of communication can operate simultaneously.

(a) Calculate the symbol rate (in baud) of both the upstream and downstream channels. [4 marks]

(b) Calculate the bandwidth occupancy of the system, if the duplexing is operated over Frequency Division Duplexing (FDD) and the guard band used to separate the two directions of communications is 500KHz. [4 marks]

(c) Calculate the symbol rate (in baud) of the system if duplexing is operated through Time Division Duplexing (TDD), and the guard times introduce a overhead of 10%. [4 marks]

(d) Calculate the bandwidth occupancy of the TDD system. [3 marks]

5. A transmission link over copper cable is required to achieve a minimum Bit Error Rate (BER) of 10^{-5}. The total link length is 1.4km and the loss of the cable 0.05 dB/m. The receiver sensitivity is -65 dBm and its noise figure is 2dB. The transmitter has a transmission power of 20 mW and a Signal-to-Noise Ratio (SNR) of 88dB and has a symbol rate of 1GBaud.

(a) Taking into consideration the BER curves in Figure 1 in the next page, can your system achieve a bit rate of 2 Gb/s? [10 marks]

(b) Taking into consideration the BER curves in Figure 1 in the next page, what is the maximum bit rate that can be achieved? [3 marks]

(c) Consider now that the link length is increased to 4km. Taking into consideration the BER curves in Figure 1 in the next page, what is the highest bit rate you could achieve using two regenerators? [12 marks]

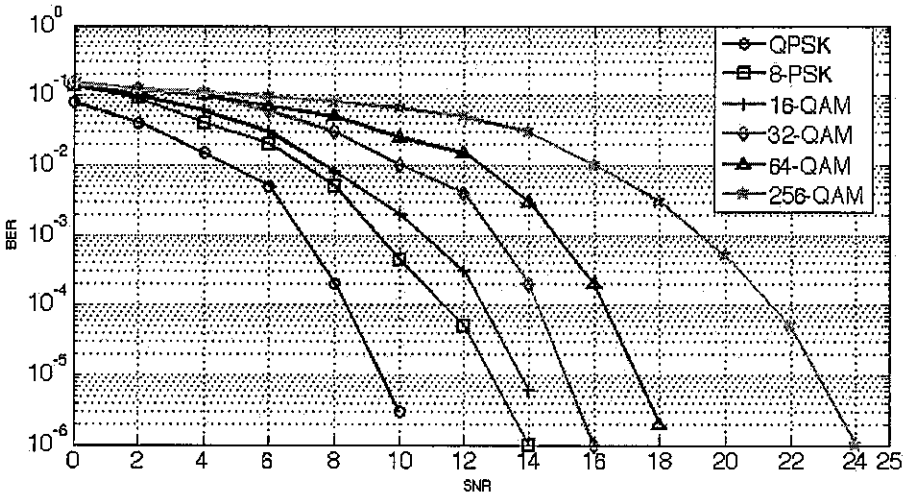

Figure 1: SNR-BER plots for different modulations

6. A square wave with frequency f=10 Hertz is approximated with its Fourier series using the first and third spectral components: $\sum_{n=1,3} 1/n * \sin(2\pi nft)$.

   (a) Show the amplitude frequency spectrum of the signal [3 marks]

   (b) Show the plot of the signal when it is amplitude modulated with a carrier sinusoid of frequency 100 Hz. [4 marks]

   (c) What would be the minimum frequency to use for the carrier sine wave? Explain why. [3 marks]

7. You need to transmit a non-compressed 4K Ultra-High Definition TV channel, with resolution of 3840x2160 pixels, 24 bits color depth per pixel and a frame rate of 50 frames per second.

   (a) What is the bandwidth required to transmit it over an 8-level Frequency Shift Keying modulation, assuming a value of d=0? [5 marks]

   (b) Assume the channels is affected by noise: the signal is transmitted with a power of 0 dBm, and the channel introduces a noise of -40 dBm. What is the minimum theoretical bandwidth required for the channel, according to the Shannon capacity theorem? [5 marks]