UNIVERSITY OF DUBLIN
TRINITY COLLEGE

Faculty of Engineering, Mathematics and Science

School of Computer Science & Statistics

Junior Freshman Integrated Computer Science **Hilary Term**

CS1031 – Telecommunications I

Tuesday 7th May 2013 **Goldsmith Hall** **09:30 - 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. Suppose you want to transmit 24 channels of an analogue phone system over a single coaxial cable, using frequency division multiplexing.

   (a) What is the total bandwidth occupied if each channel has a baseband bandwidth of 4KHz, the guard interval used is 500 Hz, and you want to keep the first channel in baseband? [4 marks]

   (b) Describe how signals are demultiplexed back into audible phone signals, and explain why are guard intervals required. [6 marks]

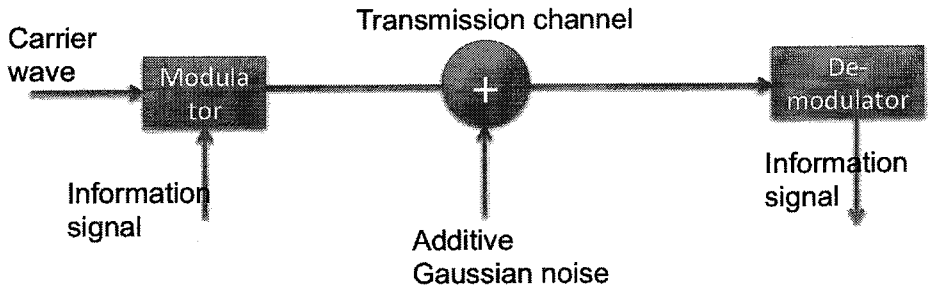
2. A new digital high-definition phone system is being tested, able to capture voice frequencies up to 20KHz, and is being encoded using 16 bits per channel. The system can carry 24 such channels using Time Division Multiplexing.

   (a) What is the total bit rate of the multiplexed system? Are guard bands required? [6 marks]

   (b) What is the minimum bandwidth required to transmit the multiplexed stream over a baseband multi-level coding system that uses 3 bits per symbol? [4 marks]

   (c) What is the minimum bandwidth required to transmit the multiplexed stream over a 256-QAM modulation? [5 marks]

3. Given the transmission diagram shown in the figure, which analogue modulator and demodulator would you use? Explain why. [5 marks]



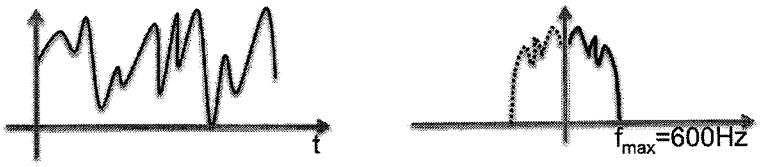
4. Describe, showing appropriate diagrams, Time Division Multiplexing and Frequency Division Multiplexing, and state the main differences between the two. Then name at least one application for each of the two multiplexing schemes. [15 marks]

5. A song encoded at compact disk (CD) quality is being streamed over an 8-PSK modulation (remember that CD quality requires the ability to reproduce a maximum frequency of 22.05 KHz, it is stereo and is encoded at 16 bits).

   (a) What is the minimum bandwidth occupied by the modulation? Why it is not possible to reduce the bandwidth any further? [6 marks]

   (b) If the signal is transmitted with a power of -10 dBm, and the channel introduces a noise of -60 dBm, what would be the minimum theoretical bandwidth required for the channel? [4 marks]

6. The figure below shows a signal in the time domain (on the left) and its associated spectrum (on the right). You are trying to digitalise the time-domain signal by sampling it at difference frequencies of, respectively, 1KHz, 1.2KHz and 1.4KHz. Show with a frequency plot, the spectra generated by a Discrete-Time-Fourier-Transform (DTFT) at the three different sampling frequencies, then give a detailed description of your drawings, and state whether information is lost during each of these sampling processes. [10 marks]



7. (a) Describe what signal duplexing means, how is operated and why it is different from signal multiplexing. [4 marks]

   (b) Describe the difference between frequency and time duplexing, showing diagrams for the two cases. [6 marks]

8. A transmission link over copper cable is being designed to operate at a minimum Bit Error Rate (BER) of 10^{-3}, using an 8-PSK modulation (the SNR-BER graph is reported in the figure). The total link length is 700m, the loss of the cable 0.1 dB/m. The receiver sensitivity is -60 dBm while the power of the transmitter is 0.4 mW, and the Signal-to-noise ratio (SNR) at the transmitter is 90dB. In addition the receiver adds a noise of 5dB at the end.

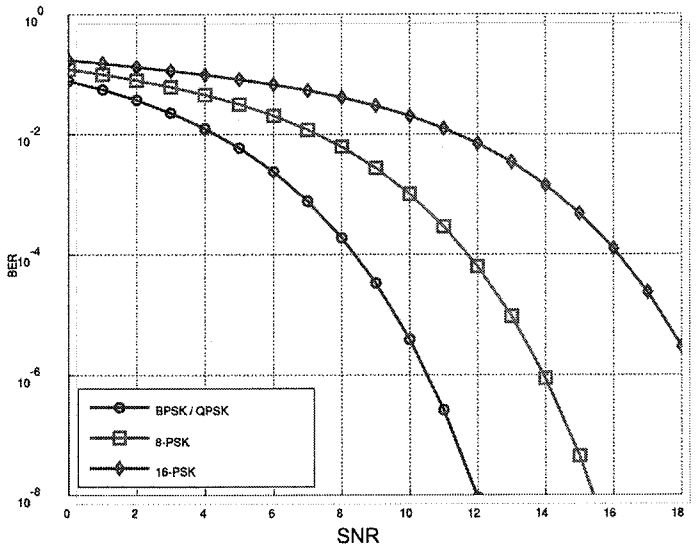


Figure 1: SNR-BER plots for different PSK modulations

(a) The first stage of the design does not include any amplifier or regenerator. Show, reporting the appropriate calculations, why this design does not satisfy the system requirements. [20 marks]

(b) What actions could you take to make the link work according to the requirements? List your options, then suggest your preferred option and explain qualitatively your choice. [5 marks]