

UNIVERSITY OF DUBLIN TRINITY COLLEGE

Faculty of Engineering, Mathematics and Science

School of Computer Science & Statistics

**Integrated Computer Science Programme
Year 1 Annual Examinations**

Trinity Term 2014

CS1031 – Telecommunications I

Friday, 9th May 2014

RDS Main Hall

14:00 – 16:00

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. A voice conversation has a frequency spectrum similar to the one shown in Figure 1. You need to transmit the voice signal over a walkie talkie radio, operating at a carrier frequency of 500 MHz. The radio is digital, so you need to sample, quantise and modulate the signal. You are also required to carry out the appropriate steps to reduce the bandwidth occupancy of the modulated signal to less than 12 KHz, while keeping the quality of the signal suitable for a voice conversation.

Your task is to specify the sampling, quantization and modulation you need to use to fit your modulated signal into the allowed 12 KHz bandwidth, if the maximum number of levels allowed by your modulator is 64. Then show a plot of the spectrum of the modulated signal.

[10 marks]

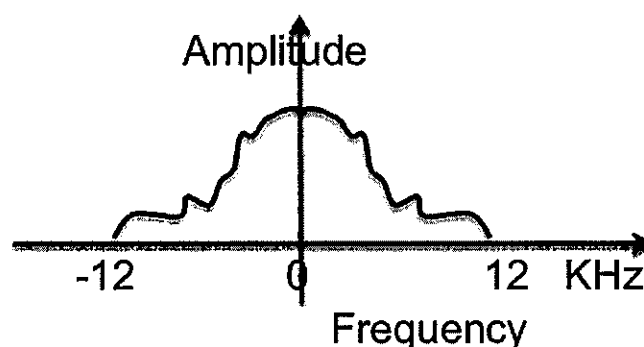


Figure 1: Sample frequency spectrum of a voice signal

2. Frequency Division Multiplexing (FDM) is a technique used to combine multiple signals into one channel.
 - (a) Describe, showing appropriate diagrams, the Frequency Division Multiplexing concept and the steps required to multiplex and demultiplex a number of phone conversations. [10 marks]
 - (b) You need to design a FDM system multiplexing 20 High-Definition TV channels. Each channel has a resolution of 1920x1080 pixels, it uses 24 bits for quantization (8 bits per colour) and displays 24 frames per second. After this an encoder is used to compress the bit rate by a factor of 50. Draw the multiplexer scheme, selecting the correct digital modulation to keep the multiplexed system within a bandwidth of

120MHz (consider a value of $d=1$ for the modulation, and, for simplicity, that no guard bandwidth is needed). [10 marks]

3. Time Division Multiplexing (TDM) is a technique used to combine multiple signals into one channel.

(a) Describe, showing appropriate diagrams, the Time Division Multiplexing concept, and how the multiplexer and demultiplexer work. [7 marks]

(b) Compare TDM and FDM, including advantages and disadvantages of the two multiplexing techniques. [3 marks]

(c) Specify the requirements for a TDM system carrying 50 phone calls. Each phone call has a maximum bandwidth of 4 KHz and needs to be digitalized using 8-bit quantization. What is the total minimum bandwidth required by the system if the multiplexed signal is transmitted in baseband? [5 marks]

4. A transmission link over copper cable is being designed to operate at a minimum Bit Error Rate (BER) of 10^{-5} . The total link length is 550m and the loss of the cable 0.1 dB/m. The receiver sensitivity is -60 dBm and its noise figure is 5dB. The maximum symbol rate for the transmitter is 1 Gbaud, the transmission power is 2 mW and the Signal-to-noise ratio (SNR) is 70dB.

(a) Taking into consideration the BER curves in Figure 2, what is the maximum bit rate achievable by the system without using any amplifier or regenerator? [15 marks]

(b) Taking into consideration the BER curves in Figure 2, re-design the system with any amplifier and/or regenerators required to achieve a bit rate of 16 Gb/s. [10 marks]

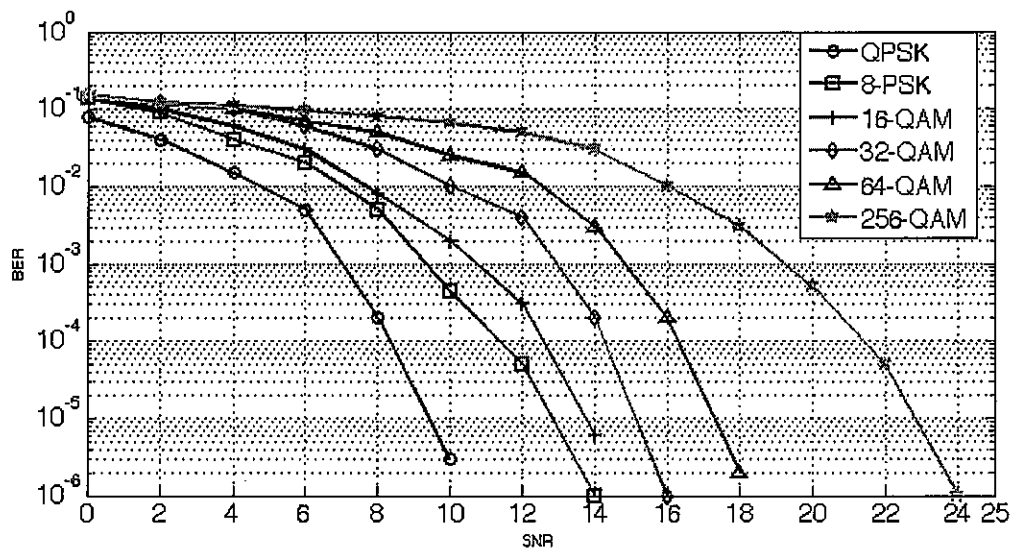


Figure 2: SNR-BER plots for different modulations

5. You need to transmit the following sequence of bits over a transmission channel, using a 8-ASK digital modulation: 100110010111001011.
- Draw a plot of the modulated signal in the time domain. [5 marks]
 - Draw a plot of the modulated signal in the frequency domain using the following parameters: the symbol rate of the modulated signal is 1 Mbaud, the carrier frequency is 100MHz and the value of d for the modulation is equal to 1. [5 marks]
6. An electronic signal generator produces a sawtooth wave with a base frequency of 1MHz. Assume you can represent the signal using the first 5 components of the following Fourier series: $\frac{2}{\pi} * \sum_{k=1}^5 (-1)^k \frac{\sin(2\pi f k t)}{k}$
- Draw the amplitude spectrum of the signal. [4 marks]
 - What is the minimum sampling frequency you should use if you want to digitalize the Fourier approximation given above of the triangle wave? Draw the Discrete-Time Fourier Transform (DTFT) of the sampled signal if you use a sampling frequency of 20 MHz. [6 marks]
 - What happens if you use a sampling frequency of 8 MHz? Draw the DTFT plot in this case. [5 marks]

7. You need to transmit a voice signal over a transmission channel which is affected by Gaussian additive (amplitude) noise. State whether it is better to use a digital or an analogue modulation and explaining your choice. Then state whether you would use amplitude, frequency or phase modulation, and explain your choice. [5 marks]