University of Glasgow

Degrees of MEng, BEng, MSc and BSc in Engineering

Digital Communications 4 (ENG4052)

Friday 11 December 2015
13:00 – 15:00

Time 120 minutes. Total 100 marks

Attempt ALL questions in Section A,
any ONE question from Section B and any ONE question from Section C

The numbers in square brackets in the right-hand margin indicate the marks allotted to the part of the question against which the mark is shown. These marks are for guidance only.

An electronic calculator may be used provided that it does not have a facility for either textual storage or display, or for graphical display.

Continued overleaf

SECTION A: Attempt ALL questions [40 marks]

Q1 (a) Define the term “Symbol” as applied to digital communications. [2]

(b) What is the central idea underlying the method whereby intersymbol interference can be avoided in a bandlimited channel with a brick-like bandwidth? [2]

(c) The Inverse Fourier Transform in Orthogonal Frequency Division Multiplexing (OFDM) generates symbols which require a certain kind of bandpass modulator. What kind of bandpass modulator is required to be able to transmit these symbols? [2]

(d) How many bits/symbol are transmitted via 4QAM and how would you assign the bits to the constellation? [4]

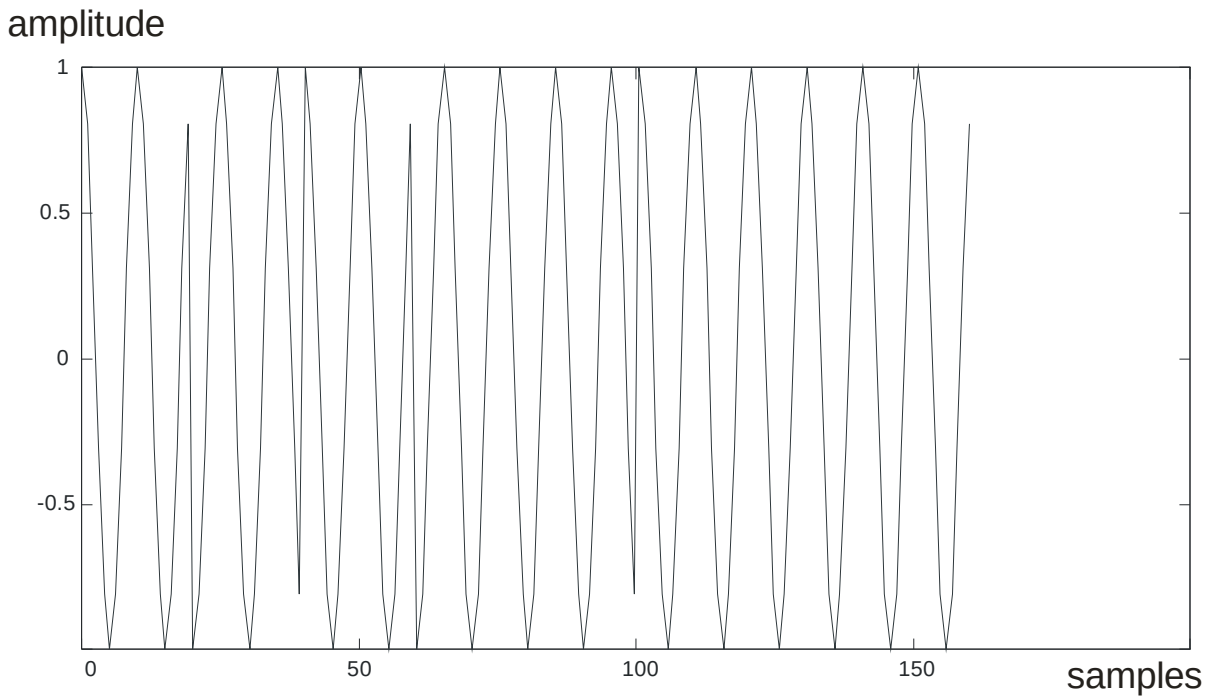


Figure Q2

Continued overleaf

Q2 (a) Figure Q2 shows a BPSK signal which is encoded with a cosine, starts at phase zero and starts with a binary '1'. The frequency of the signal is f=0.1 in normalised frequencies and the symbol interval is T=20 samples. Which bit values have been transmitted? [5]

(b) Draw the block diagram of a Costas loop for BPSK which recovers the carrier and describe the idea behind it. [5]

Q3 (a) Summarise the main features of 3rd generation mobile phone systems. How do they achieve higher capacities and higher data rates? [7]

(b) How does UMTS implement asymmetrical communication and different data rates? [5]

Q4 Which components in UTRAN can perform combining/splitting at what handover situation? What is the role of the interface $\boldsymbol{I_{ur}}$? [8]

Continued overleaf

SECTION B: Attempt ONE question [30 marks]

Q5 (a) DVB-T uses a sampling rate of 9.1473 MHz for the complex coefficients. Out of the 8192 frequency samples of the (Inverse) Fast Fourier Transform it uses 6818 samples.

(i) What is the bandwidth of the DVB-T signal? [5]

(ii) What is the duration of one symbol (without any cyclic prefix)? [5]

(b) One wants to encode 256 bytes / symbol with the help of OFDM. The bytes are coded as 4QAM. How many frequency coefficients are required theoretically and practically? Give at least one reason why the practical length will most likely differ from the theoretical one. [10]

(c) The guard interval (also called cyclic prefix) in DVB-T transmission can be set between 1/4 down to 1/16 of the symbol length. Discuss the advantages and disadvantages of different guard intervals and why in urban environments usually a shorter guard interval is used and in rural areas a longer one. [10]

Continued overleaf

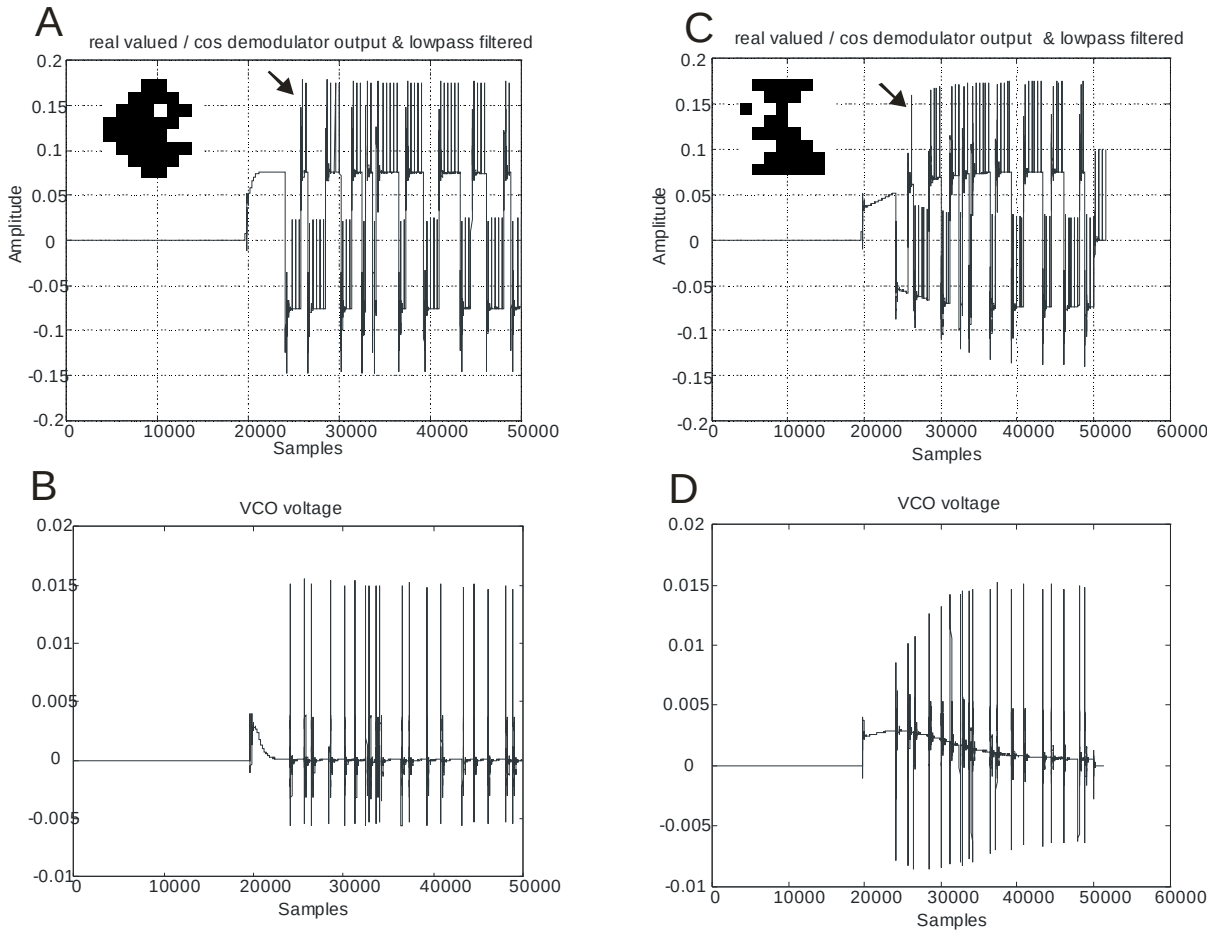


Figure Q6

Q6 Figure Q6 shows the result from two BPSK transmissions with carrier recovery using a 2nd generation Costas loop. A,C show the outputs from the demodulators and B,D the VCO control voltages. The binary image which was transmitted was that of a Pacman, as shown in the insert of A, C, which is properly decoded in A,B but is faulty in C,D. The small spikes (the arrows point to the first samples) in A,C have been added to show when the data has been sampled.

(a) Which parameter has been most likely badly tuned in C,D in contrast to A,B? [10]

(b) What are the origins of the small spikes in B,D? [10]

(c) Describe at least two steps which are required to detect the start of the data sequence (i.e. the Pacman). [10]

Continued overleaf

SECTION C: Attempt ONE question [30 marks]

Q7. (a) What is E-UTRAN? [4]

(b) List all the LTE Network elements?. [4]

(c) Describe each LTE Network element in detail. [16]

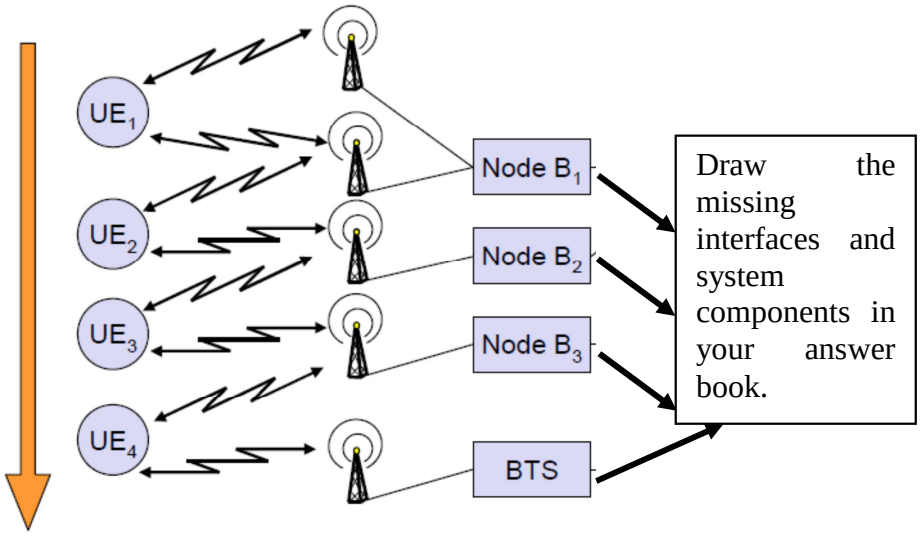
(d) What is carrier aggregation in LTE-Advanced? [6]

Q8 3G (UMTS) is a separate mobile phone technology and it provides a convergence between fixed and mobile services. Not only will this convergence lead to better use of the available spectrum, it will lead to mobile terminals that fulfill multiple functions.

(a) Briefly describe UMTS frame structure. [6]

(b) Complete the missing interfaces and system components in the diagram below [6]

(c) Briefly describe how the four handover types can possibly take place in UMTS/ GSM (as shown in the diagram below). [8]



Continued overleaf

(d) How does soft/softer handover work? [5]

(e) Why is there “soft handover gain”? [5]

End of question paper