COMP 28512

Two hours

Question ONE is COMPULSORY

UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE

Mobile Systems

Date: Wednesday 7th June 2017

Time: 14:00 - 16:00

Please answer Question ONE and also TWO other Questions from the remaining THREE Questions provided

---

This is a CLOSED book examination

The use of electronic calculators is permitted provided they are not programmable and do not store text

[PTO]

1. **Compulsory**

Answer all ten of the following short questions (worth 2 marks each)

a) Assuming that the capacity of your mobile phone battery is 12000 joules, and that electricity costs £0.15 per kilowatt-hour, estimate how much money it costs to charge up your mobile phone. State any assumptions that you make.

b) What is meant by 'aliasing distortion' and why would it be undesirable in music produced by a smartphone? How can aliasing distortion be avoided?

c) What is meant by frequency-domain processing? Give an example of what it can achieve.

d) Explain what is meant by a 'line spectrum' and an 'FFT magnitude spectrum'.

e) What are the main characteristics of Huffman coding as used for psycho-acoustic music (mp3) encoding and also for JPEG image encoding?

f) Explain what is meant by 'binary frequency shift keying' as used by second generation GSM mobile phone networks. What are the main advantages and disadvantages in comparison to other modulation techniques such as 'amplitude shift keying' (ASK) and 'code division multiple access' (CDMA)?

g) Describe the standard 'Carrier Sense Multiple Access' (CSMA) protocol as used by smartphones accessing WiFi networks. How is it different from 'Aloha' protocols?

h) What are the characteristic features of an 'event-driven' system? Why does designing a real-time digital system to be 'event-driven' help to minimise its power consumption?

i) How do the 'interactive real time' requirements of voice telephony differ from the requirements of streaming media (speech, music and video) applications?

j) Why is it considered good practice to use XML code rather than Java code to implement graphical user interface (GUI) related functionality in Android?

2. This question is about cellular mobile networks and WiFi

a) How are cellular mobile phone networks different from WiFi networks? (6 marks)

b) Explain the terms 'circuit switching' and 'packet switching' as applied to mobile communications networks. What are the main advantages and disadvantages of each of these mechanisms? Which of these mechanisms are used for voice communications by second (2G) and third (3G) generation mobile telephony? How does 4G telephony deal with voice traffic currently and how may this change in future? (8 marks)

c) Explain how the 'code division multiple access' (CDMA) multiplexing mechanism used by the third generation of cellular mobile telephony (3G) is able to share a radio spectral band in any given cell among many users. What are the three main advantages of CDMA over the mechanism used by 2G-GSM telephony? (6 marks)

[PTO]

3. This question is concerned with designing low-power systems-on-chip for mobile devices.

a) Give an expression which indicates how the dynamic power requirement, P, of a CMOS processor is dependent on the clock frequency (f_{clock}) , the power-supply voltage (V_{DD}), and the capacitive load (C_g) and estimated switching activity (α_g) for each gate g on the chip. Give two reasons why this expression become invalid or inaccurate for very low values of V_{DD} ? (4 marks)

b) Show that reducing the clock frequency of a CMOS processor does not directly improve its power-efficiency in terms of energy per instruction. What additional change in the circuit operating conditions does a reduced clock frequency allow that can improve power-efficiency? . (3 marks)

c) How could you modify the design of a CMOS processor, and the way it is used in a mobile
phone, in such a way that an overall improvement in power-efficiency, in terms of energy per instruction, is obtained? In answering this question, consider the terms f_{clock}, V_{DD}, C_g and α_g and explain why your modifications have the desired effect. (7 marks)

d) What features of the ARM processor make it well suited to smartphones? (4 marks)

e) How can the use of forward error correction (FEC) in cellular mobile systems increase their energy efficiency and also the effectiveness of spatial multiplexing by frequency re-use? (2 marks)

4. This question is about bit-error control and the effect of bit-errors on telephone speech quality

a) What is meant by 'interleaving' in a bit-stream, and why is it beneficial when using forward error correction? (2 marks)

b) A 4-bit integer M_3 M_2 M_1 M_0 is Hamming coded by including three additional bits P_2, P_1 and P_0 to allow the correction of any single bit-error that may result from its radio transmission by a mobile system. Show how a suitable set of three additional bits may be derived for the given 4-bit integer and explain how the correction would be done, if necessary, at the receiver. (6 marks)

c) Assume a smartphone uses 1 watt to transmit speech at 128 kbits per second. If the battery holds 21600 joules, how many minutes of talk time will be possible before it becomes completely discharged, neglecting energy consumed by other functions of the phone? Estimate the average energy per bit (E_b) at the receiver, assuming that there is a 50 dB power loss over the channel from transmitter to receiver. Hence calculate the value of E_b/N_0 in dB at the receiver, given that the noise has power spectral density:

$$N_0 = 8.8\text{x}10^{-12} \text{ watts/Hz.}$$ (4 marks)

d) Assume that the modulation method in part 4(c) is 'binary msk' as used in 2G mobile telephony. For this modulation method, the well known graph in Figure 1 plots the expected bit-error probability over a range of values of E_b/N_0. Figure 2 shows a graph of PESQ speech quality measurement against bit-error probability for uniformly quantised telephone speech digitised at 128 kb/s. Using these graphs, estimate the expected bit-error probability and PESQ score at the receiver What is the significance of the PESQ score obtained. (3 marks)

e) Assume that to increase the talk-time on the mobile phone, the transmission power is reduced from 1 watt to 0.75 watts. Estimate by how much time the talk-time would be increased and how the PESQ measurement of speech quality would be affected? (5 marks)

[PTO]

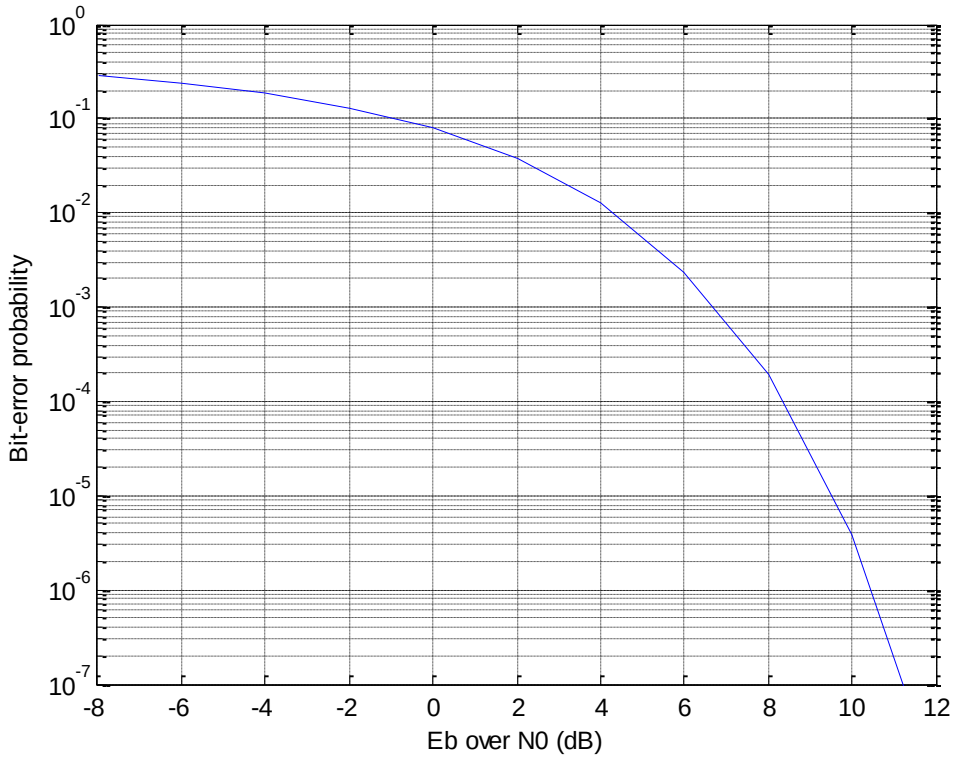

Figure 1: Graph of bit-error probability against Eb/N0 for binary msk

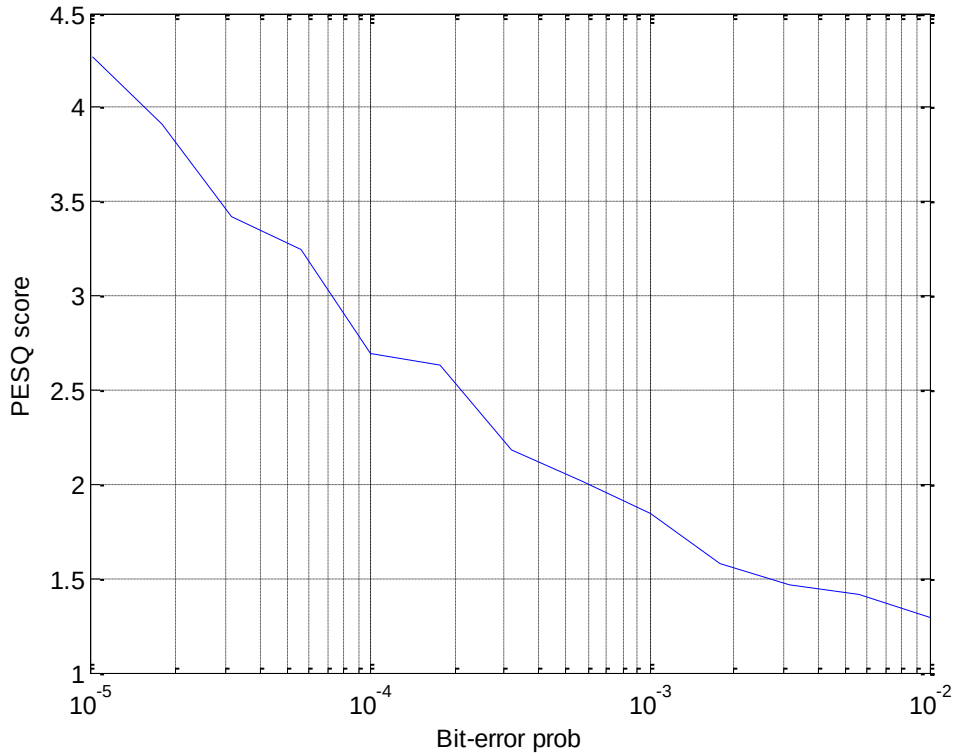

Figure 2: Graph of PESQ score against bit-error probability for telephone quality speech digitized at 128 kb/s.

END OF EXAMINATION