



北京邮电大学



EBU5302 A

Complete the information below about yourself very carefully.

QM student number

BUPT student number

Class number

Joint Programme Examinations 2019/20

For examiners' use only

EBU5302 Telecommunications Systems

Paper A

Answer ALL questions

1	
2	
3	
4	
Total	

Only regular scientific calculator allowed. No SMART PHONE calculator is ALLOWED.

Make and type of any electronic calculator you are using _____

INSTRUCTIONS

1. You must not take answer books, used or unused, from the examination room.
2. Write only in black or blue pen and in English.
3. Do all rough work in the answer book – do not tear out any pages.
4. If you use Supplementary Answer Books, tie them to the end of this book.
5. Write clearly and legibly.
6. Read the instructions on the inside cover.

Examiners

Dr Yuanwei Liu, Dr. Md Hasanuzzaman Sagor

Instructions

Before the start of the examination

- 1) Place your BUPT and QM student cards on the corner of your desk so that your picture is visible.
- 2) Put all bags, coats and other belongings at the back/front of the room. All small items in your pockets, including wallets, mobile phones and other electronic devices must be **placed in your bag in advance. Possession of mobile phones, electronic devices and unauthorised materials is an offence.**
- 3) Please ensure your mobile phone is switched off and that no alarm will sound during the exam. **A mobile phone causing a disruption is also an assessment offence.**
- 4) Do not turn over your question paper or begin writing until told to do.

During the examination

- 1) You must not communicate with or copy from another student.
- 2) If you require any assistance or wish to leave the examination room for any reason, please raise your hand to attract the attention of the invigilator.
- 3) If you finish the examination early you may leave, but not in the first 30 minutes or the last 10 minutes.
- 4) For 2 hour examinations you may **not** leave temporarily.
- 5) For examinations longer than 2 hours you **may** leave temporarily but not in the first 2 hours or the last 30 minutes.

At the end of the examination

- 1) You must stop writing immediately – **if you continue writing after being told to stop, that is an assessment offence.**
- 2) Remain in your seat until you are told you may leave.

- ### Question 1

Question 1

Question 1

[illegible]

[illegible]

c) A source emits 5 symbols (A, B, C, D, E) with probabilities as shown in **Figure 2**.

A	B	C	D	E
0.4	0.2	0.2	0.1	0.1

Figure 2

- i) Calculate the entropy of the source

[2 marks]
- ii) Compare the answer in (i) with the number of bits/symbol that would have to be used if the symbols were to be encoded without any consideration of the probability.

[2 marks]
- iii) Code this data with a Huffman variable-length code representing each symbol and determine the average number of bits/symbol that could be used to transmit this source.

[6 marks]

[illegible]

[illegible]

Question marking: $\frac{6}{6} + \frac{9}{9} + \frac{10}{10} = \frac{25}{25}$

Question 2

A digital information source produces binary sequences at a rate of 2 kbps. The probability of producing the value 0 is $p_0 = 0.2$. A Hamming code with the following parity check matrix \mathbf{H} is employed to protect information against errors:

$$H = \begin{pmatrix} \hat{e} & 1 & 0 & 1 & 1 & 1 & 0 & 0 \\ \hat{e} & 1 & 1 & 0 & 1 & 0 & 1 & 0 \\ \hat{e} & 1 & 1 & 1 & 0 & 0 & 1 & 0 \\ \hat{e} & 0 & 1 & 1 & 1 & 0 & 0 & 1 \end{pmatrix}$$

The resulting binary sequences are transmitted through an AWGN digital channel with a bandwidth $W = 20$ kHz and a SNR = 20 dB.

- a) Determine the information rate of the digital information source and the channel capacity. According to the channel-coding theorem, can the information produced by the source be transmitted through the digital channel without errors?

[6 marks]

[illegible]

[illegible]

- b) Based on the parity check matrix \mathbf{H} , determine the length of the input information sequences and the length of the code words. Calculate the code rate of this Hamming code and the resulting transmission rate.

[3 marks]

[illegible]

	3 marks
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- c) How can the code words of this Hamming code be obtained? Find out the code words corresponding to the information sequences 0100 and 1000.

[6 marks]

[illegible]

	6	marks
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- d) How can the minimum distance be obtained? Determine the number of errors can be detected and corrected in this Hamming code.

[5 marks]

[illegible]

- e) Decode the following received sequence $\mathbf{y} = 1010101$.

[5 marks]

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[illegible]

Question marking: $\frac{1}{6} + \frac{1}{3} + \frac{1}{6} + \frac{1}{5} + \frac{1}{5} = \frac{1}{25}$

Question 3

a) For the binary value of 1011001, draw the line coding signalling format of

- i) Unipolar RZ
- ii) Bipolar RZ
- iii) Manchester NRZ

[6 marks]

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		6 marks

b) What important information eye patterns can provide about the characteristics of a signal?
Briefly explain them.

[4 marks]

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[illegible]

- c) Calculate the autocorrelation function $R(k)$ of the unipolar NRZ signalling assuming bit to bit data independence and equally likely occurrence of two voltage levels.

[7 marks]

[illegible]

[illegible]

- d) A binary waveform of 12 kbits/s is converted into a 16-level waveform that is passing through a channel with a raised cosine roll-off Nyquist filter. The channel has a conditional (equalised) phase response out to 2.25 KHz:
- i) What is the baud rate?
 - ii) What is the roll-off factor?

[5 marks]

[illegible]

	5 marks

e) What types of synchronisation are usually used in digital communications?

[3 marks]

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Question marking: $\frac{1}{6} + \frac{1}{4} + \frac{1}{7} + \frac{1}{5} + \frac{1}{3} = \frac{1}{25}$

Question 4

- a) Explain the characteristics of amplitude-shift keying (ASK), frequency-shift keying (FSK) and phase-shift keying (PSK). Assuming that the digital data to be transmitted is 00110100010, please draw the analog waveforms of modulating for digital data above for ASK, binary FSK and binary PSK.

[6 marks]

[illegible]

[illegible]

- b) OFDM is widely used in current 4G communication systems.

- i) What is OFDM short for?

[1 marks]

- ii) Please explain the key advantages of OFDM.

[2 marks]

- iii) Illustrate the purpose of Cyclic Prefix (Guard Interval) for OFDM symbols in time domain by showing the direct and delayed paths. You may want to use diagrams to explain your answer.

[6 marks]

- iv) What are the key differences of single carrier systems, multi-carrier systems and OFDM systems? You may want to use diagrams to explain your answer.

[illegible]

[illegible]

[illegible]

- c) In cellular communication systems, cells sufficiently distant from each other can use the same channel (frequency).
- i) Please use mathematical approaches with possible geometry diagrams to show the relationships between cluster radius (R_u) and cell radius (r). (Assuming a is distance between i cells, b is distance between j cells, your final expressions of R_u can be expressed by i, j, r). You may want to use cluster size $N=7$ as an example to show your derivations.

[5 marks]

- ii) What is the effect of cluster size for frequency reuse in the cellular communication systems?

[2 marks]

[illegible]

[illegible]

	7 marks

Question marking: $\frac{1}{6} + \frac{1}{12} + \frac{1}{7} = \frac{1}{25}$

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Rough Working

Page 26 of 27

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Page 27 of 27