Use this section for rough work

北京郵電大學

Queen Mary University of London

EBU5302 A

Complete the information below about yourself very carefully.

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Joint Programme Examinations 2015/16

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EBU5302 Telecommunications Systems

Paper A

Answer ALL questions

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 Yue Gao, Dr Yan Sun

Filename: 1516_EBU5302_A No answerbook required

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Question 1

Let x(t) be a band-limited signal to W = 2 kHz, amplitude $0 \leq x(t) \leq 2$ and power P = 1. Signal x(t) is sampled at a rate 20% higher than the Nyquist rate to provide a guard band. The maximum acceptable error in the sample amplitude (the maximum quantization error) is 0.5% of the peak amplitude. The quantized samples are binary coded.

Assume "Sr" is an M=8 symbol source. Symbol A…. H represent each of the symbol amplitude values generated by the quantiser. The probability pm of each symbol is shown in the following table:

Table 1

m	A	B	C	D	E	F	G	H
P(m)	0.3	0.1	0.06	0.25	0.04	0.05	0.18	0.02

a) Using diagrams to explain why in general sampling has to meet the Nyquist sampling theorem.

[4 marks]

b) Illustrate what the sample rate for x(t) is.

[1 mark]

c) Find the minimum bandwidth of a channel required to transmit the encoded binary signal.

[6 marks]

d) If 24 such signals are time-division-multiplexed, determine the minimum transmission bandwidth required to transmit the multiplexed signal.

[1 mark]

e) What is the information content for each symbol of Sr?

[9 marks]

f) What are the source entropy and source efficiency for Sr?

[4 marks]

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Question 2

A digital information source produces binary sequences at a rate of 5 kbps. The probability of producing the value 0 is $p_0 = 0.2$. A Hamming code with the following parity check matrix H is employed to protect information against errors:

$$H = \begin{bmatrix} 1 & 0 & 1 & 1 & 1 & 0 & 0 \\ 1 & 1 & 1 & 0 & 0 & 1 & 0 \\ 0 & 1 & 1 & 1 & 0 & 0 & 1 \end{bmatrix}$$

The resulting binary sequences are transmitted through a wireless channel where power falloff with distance follows the formula $P_r(d) = P_t(d_0/d)^3$ for d_0=10m. Assume the channel has bandwidth B=30 kHz and AWGN with noise PSD (power spectral density) $N_0/2$, where N_0 = 10-9 W/Hz.

a) For a transmit power of 1 W, find the capacity of this cannel for a transmit-receive distance of 100m and 1km.

[6 marks]

b) Based on the parity check matrix 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.

[4 marks]

c) How can the systematic linear block code words of this Hamming code be obtained? Calculate the code words corresponding to the information sequences 0110 and 1010.

[5 marks]

d) Determine the number of errors can be detected and corrected in this Hamming code.

[5 marks]

e) Decode the following received sequence r = 1111010.

[5 marks]

Use this section for rough work

Question 3

a) A multilevel digital communication system sends one of 16 possible levels over the channel every 0.8 ms.

i) What is the number of bits corresponding to each level?

ii) What is the baud (Symbol) rate?

iii) What is the bit rate?

[6 marks]

b) Multilevel data with an equivalent bit rate of 2,400 bits/s is sent over a channel using a four level line code that has a rectangular pulse shape at the output of the transmitter. The overall transmission system (i.e. the transmitter, channel and receiver) has an r=0.5 raised cosine roll-off Nyquist filter characteristic.

i) Find the baud (symbol) rate of the received signal.

ii) Find the 6-dB bandwidth for this transmission system.

iii) Find the absolute bandwidth for the system.

[8 marks]

c) The following table illustrates the operation of an FHSS system for one complete period of the PN sequence.

Time	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Input data	0	1	1	1	1	1	1	0	0	0	1	0	0	1	1	1	1	0	1	0
Frequency	f_{11}	f_2	f_{11}	f_3	f_3	f_3	f_{22}	f_{10}	f_0	f_0	f_1	f_{22}	f_9	f_1	f_{23}	f_3	f_{22}	f_{11}	f_3	f_{31}
PN Sequence	001	110	011	001	001	001	110	011	001	001	001	110	011	001	001	001	110	011	001	001

To determine:

i) What is the period of the PN sequence?

ii) The system makes use of a form of FSK. What form of FSK is it?

iii) What is the number of bits per symbol?

iv) What is the number of FSK frequencies?

v) What is the length of a PN sequence per hop?

vi) Is this a slow or fast FH system?

vii) What is the total number of possible hops?

viii) Show the variation of the dehopped frequency with time.

[11 marks]

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Question 4

a) If the received signal level for a particular digital system is -151dBW and the receiver system effective noise temperature is 1500 K, what is E_b/N_0 for a link transmitting 2400bps?

[2 marks]

b) Using diagrams and engineering terms to compare for same data rate transmission by using single carrier, multi-carrier and OFDM modulations, respectively.

[11 marks]

c) Derive the power spectral density (PSD) equation for the polar NRZ signalling.

[12 marks]