Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2023/2024

COURSE NAME	:	DIGITAL COMMUNICATION
COURSE CODE	:	BEJ 41103
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	JULY 2024
DURATION	:	3 HOURS
INSTRUCTIONS	:	1. ANSWER ALL QUESTIONS 2. THIS FINAL EXAMINATION IS CONDUCTED VIA ☐ Open book ☒ Closed book 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF **FIVE (5)** PAGES

Q1 (a) Define the following bandwidth criteria:

(i) Half-power bandwidth

(2 marks)

(ii) Power bandwidth

(2 marks)

(iii) Absolute bandwidth

(2 marks)

(b) Consider that a 120 kbps data stream is to be transmitted on a voice-grade telephone circuit with a bandwidth of 3 kHz.

(i) Determine the possibility of acquiring error-free transmission with a signal-to-noise ratio (SNR) of 10 dB. Justify your answer.

(3 marks)

(ii) If it is not possible, suggest **THREE (3)** system modifications that might be made.

(3 marks)

(c) Timing error occurs in synchronization as a result of frequency difference of two physically oscillators (transmitter and receiver). Analyze the effects of frequency difference in asynchronous character transmission with data rate of 10 kbps as shown in **Figure Q1** to the relative frequency error.

(8 marks)

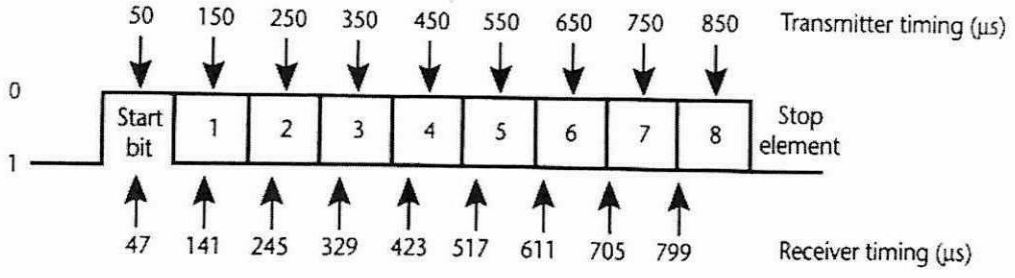

Figure Q1

Q2 (a) Consider the following code vectors:

$$U_1 = [10010]$$

$$U_2 = [01101]$$

$$U_3 = [11001]$$

(i) Determine the Hamming distance between codewords U_1 and U_2, $d(U_1, U_2)$

(2 marks)

(iii) Show that

$$d(U_1, U_2) + d(U_2, U_3) \geq d(U_1, U_3)$$

(6 marks)

(b) An analog signal having 4 kHz bandwidth is sampled at 1.25 times the Nyquist rate and each sample is quantized into one of 256 equally likely levels.

(i) Determine whether the output of this source can be transmitted without error over an adaptive white gaussian noise (AWGN) channel with a bandwidth of 10 kHz and signal-to-noise ratio (SNR) of 20 dB.

(5 marks)

(ii) Suggest the SNR required for error-free transmission for **Q2(b)(i)**.

(3 marks)

(c) State the key difference between the term multiplexing and multiple access.

(4 marks)

Q3 (a) Describe the figure of merit for the performance of analog and digital communication system.

(4 marks)

(b) Illustrate the eye patterns of distorted polar non-return to zero (NRZ) waveform for the sequence 011001 under:

(i) Ideal channel filtering

(3 marks)

(ii) Filtering that produces inter-symbol interference (ISI).

(3 marks)

(c) Feedback diversity and Maximal Ratio Combining (MRC) are two classes of space diversity reception methods. As a system engineer in a telecommunication company, you are required to choose only **ONE (1)** of the methods that gives significant benefits to the company. Justify your choice of method in terms of the implementation complexity and resulting fading statistics.

(10 marks)

Q4 (a) Discuss the concept of redundancy in error detection and error correction.

(4 marks)

(b) Coordinated Multipoint (CoMP) technology in LTE-Advanced allows multiple cell to cooperate and can be seen as a network Multiple Input Multiple Output (MIMO) system. Compare 8X8 conventional MIMO and 8X8 CoMP systems. Provide appropriate block diagrams where needed.

(10 marks)

(c) The Non-Orthogonal Multiple Access (NOMA) is a multiple access technique applied in Fifth Generation (5G) cellular wireless network. NOMA offers massive connectivity compared to Orthogonal Multiple Access (OMA) technique. Give your explanation.

(6 marks)

Q5 (a) Consider a (7,4) code with a generator matrix as follows:

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

(i) Verify the validity of the received vector 1101101.

(4 marks)

(ii) Determine the error-correcting capability of the code.

(2 marks)

(b) Interleaving is a method used to obtain time diversity in wireless communication system. If the sequence of 1011011000101100 is the input to a block interleaver, demonstrate the interleaving procedure and determine the interleaver output. Then, show how the transmitted data being recovered at the receiver.

(6 marks)

(c) The users in Long Term Evolution (LTE) networks need to know frame synchronization to be able to decode the downlink radio frame. With the aid of LTE frame structure, explain Primary Synchronization Channel (PSS) and Secondary Synchronization Channel (SSS).

(8 marks)

- END OF QUESTIONS -