Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2015/2016

COURSE NAME	:	DIGITAL COMMUNICATION
COURSE CODE	:	BEB 41803
PROGRAMME	:	BEJ
EXAMINATION DATE	:	JUNE / JULY 2016
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FIVE (5)** QUESTIONS ONLY

THIS QUESTION PAPER CONSISTS OF **EIGHT (8)** PAGES

Q1 (a) Describe the important features of a digital communication by highlighting the importance of each feature.

(6 marks)

(b) Differentiate between correlation and autocorrelation in the context of digital communication.

(4 marks)

(c) An unwanted signals present in an electronic communication system will be intepreted as noise. The presence of noise will limit the digital receiver's ability to achieve maximum rate of information transmission. Analyze why:

(i) the thermal noise cannot be eliminated? and

(3 marks)

(ii) there is a presence of noise during quantization process?

(3 marks)

(d) A baseband transmission of a 8-level Pulse Amplitude Modulation (PAM) pulse sequence having a data rate of R = 1200 bits/s. The system transfer characteristic consists of a raised-cosine spectrum with 100% excess bandwidth (r=1). Calculate the minimum required bandwidth for this transmission.

(4 marks)

Q2 (a) Prove that the same value of Effective Isotropic Radiated Power (EIRP) can be produced equally well by using a transmitter with P_t = 100 W or with P_t = 0.1 W, by employing the appropriate antenna in each case.

(3 marks)

(b) A transmitter has an output of 2 W at a carrier frequency of 2 GHz. Assume that the transmitting and receiving antennas are parabolic dishes each 1 m in diameter. Assume that the efficiency of each antenna is 0.55. Calculate:

(i) the gain of each antenna,

(4 marks)

(ii) the EIRP of the transmitted signal in units of dBW, and

(3 marks)

(iii) the available signal power at the receiving antenna if it is located 25km from the transmitting antenna over a free-space path.

(4 marks)

(c) A noise source has temperature $T_g°$=1050 K. A line at temperature of $T_0°$=280 K has a loss factor, L = 2, is fed from this source of noise temperature. Signal bandwidth is given as 2 GHz. If the input signal power, S_i, is given as 1000 pW, calculate:

(i) the input signal to noise ratio, SNR_i,

(3 marks)

(ii) the output signal to noise ratio, SNR_o.

(3 marks)

Q3 (a) Distinguish the orthogonal codeword set H_3 for 3-bit data set.

(3 marks)

(b) (i) Produce a (4,3) even-parity error-detection code such that the parity symbol appears as the leftmost symbol of the codeword.

(4 marks)

(ii) Calculate the probability of an undetected message error, assuming that the probability of a channel symbol error is $p = 10^{-3}$.

(4 marks)

(c) Generator matrix, G, is given as;

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

(i) Construct the code word for message vector 010, 101 and 111.

(6 marks)

(ii) A codeword U is given as 101110. When this codeword is transmitted, an error vector r = 001110 is received. By utilizing **Table Q3**, calculate the syndrome vector value, $S = rH^T$.

(3 marks)

Q4 (a) Digital receiver syncronization consists of phase, symbol and frame synronization. As per your knowledge, analyze the difference between 3 of them.

(6 marks)

(b) **Figure Q4(b)** shows the benefits and trade off that can be achieved with the use of channel coding. Explain in detail the benefits and trade-off for:

(i) error performace vs. bandwidth

(4 marks)

(ii) data rate vs. bandwidth

(4 marks)

(c) The heart of nearly all syncronization circuits is a version of phase-locked loop (PLL). Design and explain the THREE (3) basic elements of the PLL.

(6 marks)

Q5 (a) **Figure Q5(a)** shows the Error Probability Plane for orthogonal signalling. It explains clearly the benefits and trade-off we have to face under certain circumstances. Differentiate the benefit and trade-off happens at the labelled points **1**, **2** and **3**. You may use terms such as P_B, E_b/N_o, number of bits (k) and bandwith (BW) to assist you.

(9 marks)

(b) MFSK is termed as power efficient modulation technique because it can be used to save power at the expense of bandwidth. To minimize the required power, the ratio of received bit energy to noise-power spectral density (E_b/N_0) is given as 8.2 dBHz. The modulation level, M, has been fixed to 16 to cater the available badhwidth of 45kHz. Calculate:

(i) the symbol energy to noise power spectral density (E_s/N_0),

(3 marks)

(ii) probability of symbol error, $P_E(M)$, and

(4 marks)

(iii) probability of bit error, P_B.

(3 marks)

(c) From the calculation made in **5(b)** above, distinguish whether the modulation scheme meet the requirement or no.

(1 mark)

Q6 (a) Two CDMA users (X and Y) are transmitting digital signals. The output data from speech coder for user X is 1111000000001111 whereas for user Y is 1111111111111111. Walsh Code 1 and 2 (refer to **Table Q6(a)**) are employed at spreading code X and Y respectively. Construct in such a way that the interference between the users will be minimized, if:

(i) user Y is transmitting at user X power level.

(7 marks)

(ii) user Y is transmitting at three times user X power level.

(7 marks)

(b) A binary Phase Shift Keying (PSK) system using CDMA requires a data rate for each user of 100 kbps and has a spread spectrum bandwidth (90% in-band power) of 200 kHz.

(i) Calculate the processing gain of the system.

(2 marks)

(ii) If an SNR of 20 dB is required for adequate performance, calculate the number of users can the system support.

(2 marks)

(iii) Calculate the minimum SNR if the system can support at least 10 users.

(2 marks)

- END OF QUESTION –

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Table Q3: Syndrome Look-Up Table

Error Patern	Syndrome
000000	000
000001	101
000010	011
000100	110
001000	001
010000	010
100000	100
010001	111

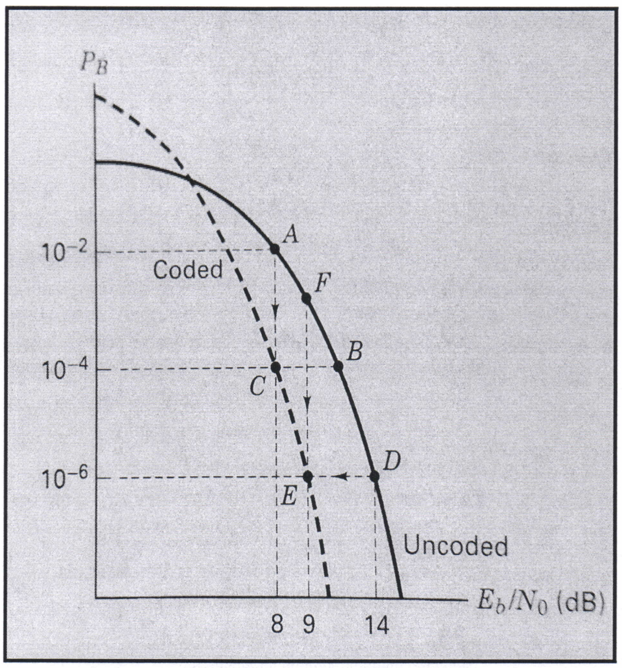

Figure Q4(b)

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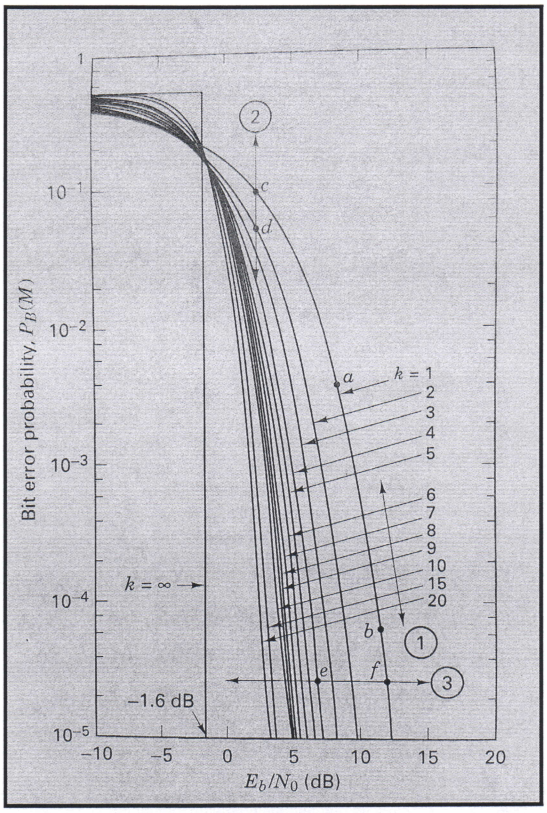

Figure Q5(a)

Table Q6(a)

Code 0	1	1	1	1	1	1	1	1
Code 1	1	1	1	1	-1	-1	-1	-1
Code 2	1	1	-1	-1	1	1	-1	-1
Code 3	-1	-1	1	1	-1	-1	1	1
Code 4	1	-1	-1	1	1	-1	-1	1
Code 5	1	-1	-1	1	-1	1	1	-1
Code 6	1	-1	1	-1	1	-1	1	-1
Code 7	1	-1	-1	1	1	-1	1	-1

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Table 3: Probability of Symbol Error and Probability of Bit-Error Equations

Modulation Type	Parameter	Equation
M-FSK	Probability of symbol error, $P_E(M)$	$P_E(M) \le \frac{M-1}{2}\exp\left(-\frac{1}{2}\frac{E_s}{N_0}\right)$
	Probability of bit-error, P_b (Uncoded system)	$P_b = \left(\frac{2^{k-1}}{2^k-1}\right)P_E$
M-PSK	Probability of symbol error, $P_E(M)$	$P_E(M) \approx 2Q\left[\sqrt{\frac{2E_s}{N_0}}\sin\left(\frac{\pi}{M}\right)\right]$
	Probability of bit-error, P_b (Uncoded system)	$P_b \approx \frac{P_E}{\log_2 M} \quad (for\ P_E << 1)$
M-QAM	Probability of bit-error, P_b (Uncoded system)	$P_b \approx \frac{2(1-L^{-1})}{\log_2 L}Q\left[\sqrt{\left(\frac{3\log_2 L}{L^2-1}\right)\frac{2E_b}{N_0}}\right]$ where $L=\sqrt{M}$
Coded System (All Modulation Type)	Probability of bit-error, P_b	$P_b \approx \frac{1}{n}\sum_{j=t+1}^{n} j\binom{n}{j}p_c^j(1-p_c)^{n-j}$
Complementary Error Function (approximation)	Q(x)	$Q(x) \approx \frac{1}{x\sqrt{2\pi}}\exp\left(-\frac{x^2}{2}\right)$ where x > 3

Boltzmann's constant, k, is given as **1.38×10^{-23} J/K**.