# UNIVERSITI TUN HUSSEIN ONN MALAYSIA

## FINAL EXAMINATION
## SEMESTER II
## SESI 2012/2013

| | | |
|---|---|---|
| COURSE NAME | : | ADVANCED COMMUNICATION THEORY |
| COURSE CODE | : | BEB 40703 |
| PROGRAMME | : | BEB |
| EXAMINATION DATE | : | JUNE 2013 |
| DURATION | : | 2 HOURS |
| INSTRUCTION | : | ANSWER **FOUR (4)** QUESTIONS ONLY. |

THIS QUESTION PAPER CONSISTS OF **SEVEN** (7) PAGES

**Q1** (a) Describe the difference between a deterministic signal and a random signal.

(5 marks)

(b) State the mathematical relationship between the correlation function and the power spectrum.

(5 marks)

(c) In a binary communication system (see FIGURE Q1/(c)), a 0 or 1 is transmitted. Because of channel noise, a 0 can be received as a 1 and vice versa. Let $m_0$ and $m_1$ denote the events of transmitting 0 and 1, respectively. Let $r_0$ and $r_1$ denote the events of receiving 0 and 1, respectively. Let $P(m_0) = 0.5$, $P(r_1|m_0) = p = 0.1$ and $P(r_0|m_1) = q = 0.2$.

(i) Find $P(r_0)$ and $P(r_1)$.
(ii) If a 0 was received, determine the probability that a 0 was sent.
(iii) If a 1 was received, determine the probability that a 1 was sent.
(iv) Calculate the probability of error $P_e$.
(v) Calculate the probability that the transmitted signal is correctly read at the receiver.

(15 marks)

**Q2** (a) Configure a (4,3) even-parity error-detection code such that the parity symbol appears as the leftmost symbol of the codeword.

(i) Identify the error patterns can the code detect.
(ii) Compute the probability of an undetected message error, assuming that all symbol errors are independent events and that the probability of a channel symbol error is $p=10^{-3}$.

(6 marks)

(b) Consider a (7,4) code whose generator matrix is

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

(i) Find the codewords of 0111, 1001 and 1011 codes.
(ii) Find H, the parity-check matrix for this code.
(iii) Compute the syndrome for the received vector 1101101. Is this a valid code vector?
(iv) Determine the error-correcting capability of the 1101101 code.
(v) Determine is the error-detecting capability of the 1101101 code.

(19 marks)

**Q3** (a) With the aid of suitable diagram, states THREE classes of multiple access techniques in communication systems.

(9 marks)

(b) A spread spectrum technology with Pseudonoise (PN)-generator and Binary Phase Shift Keying (BPSK) modulation is to be employed for Code Division Multiple Access (CDMA) interference system. Draw a suitable block diagram for the system and explain the function of each of the sub-block in the block diagram and state their mathematical expressions.

(12 marks)

(c) Describe the near far problem in CDMA multiple access interference system.

(4 marks)

**Q4** (a) Explain how Intersymbol Interference (ISI) occurs in digital transmission system and how to overcome this problem.

(5 marks)

(b) Calculate the average information in bits/character for the alphabetic characters occur with the following probabilities :

| | |
|---|---|
| p = 0.21; | for the letters a,e,o,t |
| p = 0.13; | for the letters h,i,n,r,s |
| p = 0.09; | for the letters c,d,f,l,m,p,u,y |
| p = 0.05; | for the letters b,g,j,k,q,v,w,x,z |

(5 marks)

(c) Consider an adaptive white gaussian noise (AWGN) channel with 4 kHz bandwidth and the noise power spectral density $N_O/2=10^{-12}$ W/Hz. The signal power required at the receiver is 0.1 mW. Calculate the capacity of this channel.

(5 marks)

(d) A discrete memoryless channel have five symbols $m_1$, $m_2$, $m_3$, $m_4$ dan $m_5$ with probabilities 0.4, 0.19, 0.16, 0.15 and 0.1 respectively.

(i) Construct a Shannon-Fano code for the channel.
(ii) Calculate the efficiency of the code.

(10 marks)

**Q5** (a) With the aid of suitable diagram, states 3 (three) basic components of phase-locked loop (PLL) and explain their functions.

(8 marks)

(b) An amplifier has an input and output resistance of 50Ω, a 60dB gain and a bandwidth of 10 kHz. When a 50Ω resistor at 290K is connected to the input, the output rms noise voltage is 100 μV. Determine the effective noise temperature of the amplifier.

(5 marks)

(c) Design a hypothetical experiment to measure path loss, $L_s$ at frequencies $f_1$=20 MHz and $f_2$=40 MHz, when the distance between the transmitter and receiver is 200 km. Find the effective area of the receiving antenna and calculate the path loss in decibels (dB) for each case.

(12 marks)

**- END OF QUESTION -**

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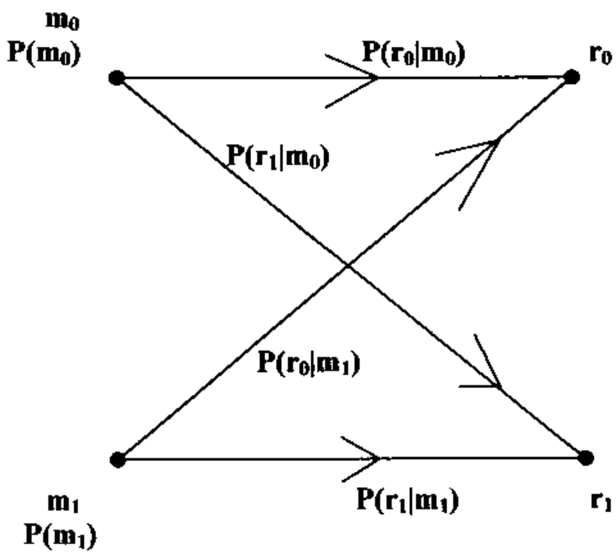


**FIGURE Q1/(c)**

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Trigonometric Identities

**Reciprocal Identities**

$\csc\theta = \dfrac{1}{\sin\theta}$ $\sec\theta = \dfrac{1}{\cos\theta}$ $\cot\theta = \dfrac{1}{\tan\theta}$

**Quotient Identities**

$\tan\theta = \dfrac{\sin\theta}{\cos\theta}$ $\cot\theta = \dfrac{\cos\theta}{\sin\theta}$

**Double Angle Formulae**

$\sin 2x = 2\sin x\cos x$

$\cos 2x = \cos^2 x - \sin^2 x$

$\cos 2x = 2\cos^2 x - 1$

$\cos 2x = 1 - 2\sin^2 x$

$\tan 2x = \dfrac{2\tan x}{1-\tan^2 x}$

**Pythagorean Identities**

$\cos^2\theta + \sin^2\theta = 1$

$\sin^2\theta = 1 - \cos^2\theta$

$\cos^2\theta = 1 - \sin^2\theta$

$\tan^2\theta + 1 = \sec^2\theta$

$1 + \cot^2\theta = \csc^2\theta$

**Addition and Subtraction Formulae (or Compound Angle Formulae)**

$\sin(x+y) = \sin x\cos y + \cos x\sin y$

$\sin(x-y) = \sin x\cos y - \cos x\sin y$

$\cos(x+y) = \cos x\cos y - \sin x\sin y$

$\cos(x-y) = \cos x\cos y + \sin x\sin y$

$\tan(x+y) = \dfrac{\tan x + \tan y}{1 - \tan x\tan y}$

$\tan(x-y) = \dfrac{\tan x - \tan y}{1 + \tan x\tan y}$

**Cofunction Identities**

$\sin x = \cos\left(\dfrac{\pi}{2} - x\right)$

$\cos x = \sin\left(\dfrac{\pi}{2} - x\right)$

$\tan x = \cot\left(\dfrac{\pi}{2} - x\right)$

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### Information Theory

$$\log_2(x) = \frac{\ln(x)}{\ln(2)}$$

$$H(x) = -\sum_i P(x_i)\log_2 P(x_i) \text{ bits / symbol}$$

$$H(x,y) = -\sum_i \sum_j P(x_i, y_j)\log_2 P(x_i, y_j)$$

$$H(y|x) = -\sum_i \sum_j P(x_i, y_j)\log_2 P(y_j|x_i) = H(x,y) - H(x)$$

$$I(x,y) = H(x) - H(x|y) = H(y) - H(y|x)$$

$$C = r \max I(x,y) \text{ bits/sec (discrete channel)}$$

$$C = B\log_2(1 + P_s/P_n) \text{ bits/sec (continuous channel)}$$

### Coding

$$P(i) = \binom{n}{i} P_b^i Q_b^{n-i} \text{ (binomial distribution)}$$

$$P_b = Q\left\{\sqrt{RE_b/\alpha}\right\} \text{ (BER before correction)}$$

$$P_{cbe} \approx \frac{2t+1}{n}\binom{n}{t+1} P_b^{t+1} \text{ (BER, correcting t errors)}$$

$$\tilde{x} = \tilde{m}G, \quad G = [I \; P] = \text{generator matrix}$$

$$\tilde{y} = \tilde{x} + \tilde{e}, \quad \tilde{s} = \tilde{y}H = \text{syndrome}$$

$$H = \begin{bmatrix} P \\ I \end{bmatrix} = \text{parity check matrix}$$

Hamming codes $n = 2^q - 1$ (correct one error per block)

$$2^q \geq \sum_{i=0}^{t} \binom{n}{i} \text{ (necessary for existence of code)}$$

### Communication Link

$$EIRP = P_t G_t \qquad F = \frac{EIRP}{4\pi R^2} = \frac{P_t G_t}{4\pi R^2} \text{ W/m}^2$$

$k$ = **Boltzmann's constant = 1.38x10$^{-23}$ J/K(-228.6 dBW/HzK)**

$$P_r = F \times A_r = \frac{P_t G_t A_r}{4\pi R^2} \qquad A_e = A_{phy} \times \eta \qquad Gain = \frac{4\pi A_e}{\lambda^2} \qquad L_p = \left(\frac{4\pi R}{\lambda}\right)^2$$

$$Gain = \frac{4\pi A_e}{\lambda^2} = \frac{4\pi A_{phy}}{\lambda^2} \times \eta \qquad \theta_{3dB} \cong \frac{75\lambda}{D} \text{ degrees} \qquad \boxed{P_r = \frac{P_t G_t G_r}{L_p L_a L_{ta} L_{ra} L_{pol} L_{other} L_r}}$$

$$N = kT_s B \text{ (dBW)} \qquad \boxed{T[K] = T[^0C] + 273} \qquad \boxed{T[K] = (T[^\circ F] - 32)\frac{5}{9} + 273}$$

$$T_s = T_{transmitted} + T_{antenna} + T_{LNA} + T_{lineloss} + T_{RX} \qquad T_{no} = T_p(1-G)$$

$$F_N = \frac{[S/N]_{in}}{[S/N]_{out}} = \frac{N_{out}}{kT_0 B_N G} \qquad T_d = T_0(F_n - 1)$$