



DEPARTMENT of ELECTRICAL and ELECTRONIC ENGINEERING  
EXAMINATIONS 2003

M.Sc and EEE/ISE PART IV: M.Eng. and ACGI

## Solutions 2003

# ADVANCED COMMUNICATION THEORY

- There are *FOUR* questions (*Q1* to *Q4*)
- Answer *Question ONE* plus *TWO* other questions.

*Comments for Question Q1:*

- *Question Q1* has 20 multiple choice questions numbered 1 to 20.
- *Circle the answers you think are correct on the answer sheet provided.*
- *There is only one correct answer per question.*

*Distribution of marks*

- Question-1: 40 marks*
- Question-2: 30 marks*
- Question-3: 30 marks*
- Question-4: 30 marks*

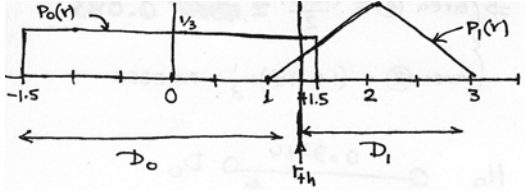
*The following are provided:*

- *A table of Fourier Transforms*
- *A "Gaussian Tail Function" graph*

Examiners responsible: Dr. A. Manikas

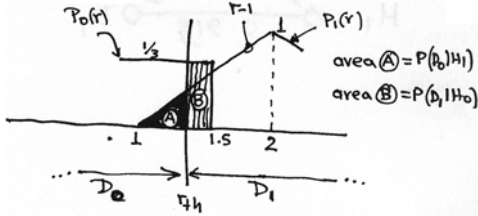
## ANSWER to Q1

- |     |   |   |   |   |   |
|-----|---|---|---|---|---|
| 1)  | A | B | C | D | E |
| 2)  | A | B | C | D | E |
| 3)  | A | B | C | D | E |
| 4)  | A | B | C | D | E |
| 5)  | A | B | C | D | E |
| 6)  | A | B | C | D | E |
| 7)  | A | B | C | D | E |
| 8)  | A | B | C | D | E |
| 9)  | A | B | C | D | E |
| 10) | A | B | C | D | E |
| 11) | A | B | C | D | E |
| 12) | A | B | C | D | E |
| 13) | A | B | C | D | E |
| 14) | A | B | C | D | E |
| 15) | A | B | C | D | E |
| 16) | A | B | C | D | E |
| 17) | A | B | C | D | E |
| 18) | A | B | C | D | E |
| 19) | A | B | C | D | E |
| 20) | A | B | C | D | E |

**ANSWER to Q2** (aim: to examine 'decision rules')

$$C_{00} \cdot \Pr(D_0|H_0) + C_{10} \cdot \Pr(D_1|H_0) = C_{11} \cdot \Pr(D_1|H_1) + C_{01} \cdot \Pr(D_0|H_1)$$

$$\Rightarrow 3 \Pr(D_1|H_0) = \Pr(D_0|H_1) \quad (1)$$



$$(1) \Rightarrow \underbrace{3(1.5 - r_{th})\frac{1}{3}}_{\text{area B}} = \underbrace{\frac{(r_{th}-1)^2}{2}}_{\text{area A}}$$

$$\Rightarrow (1.5 - r_{th}) = \frac{r_{th}^2 - 2r_{th} + 1}{2}$$

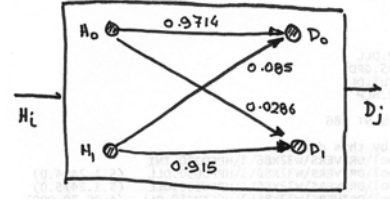
$$\Rightarrow 3 - 2r_{th} = r_{th}^2 - 2r_{th} + 1$$

$$\Rightarrow r_{th}^2 = 2$$

$$\Rightarrow r_{th} = \sqrt{2} = 1.41$$

$$\Rightarrow \begin{cases} \text{area A} = \frac{(\sqrt{2}-1)^2}{2} \simeq 0.085 \\ \text{area B} = (1.5 - \sqrt{2})\frac{1}{3} \simeq 0.02859 \end{cases}$$

$$\text{i.e. } \mathbb{F} = \begin{bmatrix} 0.9714, & 0.085 \\ 0.0286, & 0.915 \end{bmatrix}$$

**ANSWER to Q3** (aim: to examine 'Spread Spectrum Theory')

- $F_g = 4 \text{ kHz}$   
 $Q = 256 \text{ levels}$   
 $\gamma = 8 \text{ bits}$
- $P_J = 1.6 \text{ W}$   
 $N_0/2 = 0.5 \times 10^{-12}$   
 $A = 0.693 \text{ V}$   
 $p_c = 3 \times 10^{-6}$

- $r_{cs} = 2 \times 2\gamma F_g = 2 \times 2 \times 8 \times 4 \times 10^3 \text{ bits/sec}$   
 $= 128 \times 10^3 \frac{\text{bits}}{\text{sec}}$   
 $T_{cs} = \frac{1}{r_{cs}} = 7.8125 \mu\text{sec}$   
 $N_0 = 10^{-12}$   
 $B_J = 0.1 B_{ss}$   
 $E_b = \frac{4^2}{2} T_{cs} = 1.876 \times 10^{-6}$

- $p_e = \mathbf{T}\{\sqrt{(1-\rho)\text{EUE}_{equ}}\}$  ; BPSK  $\Rightarrow \rho = -1$

$$\text{Therefore } 3 \times 10^{-6} = \mathbf{T}\{\sqrt{2\text{EUE}_{equ}}\}$$

$$\Rightarrow \text{(using inverse tail-functions), } 4.6 = \sqrt{2\text{EUE}_{equ}}$$

$$\Rightarrow \frac{2 \frac{E_b}{N_0 + \frac{P_J}{B_J}}}{1} = 4.6^2$$

$$\Rightarrow B_J = \frac{P_J}{-N_0 + \frac{2E_b}{4.6^2}}$$

$$\Rightarrow B_{ss} = \frac{P_J \times 10^3}{-N_0 + \frac{2E_b}{4.6^2}} = 90.236 \times 10^6$$

(i.e. PN-code rate =  $90.236 \frac{\text{Mchips}}{\text{sec}}$ )

$$\Rightarrow T_c = \frac{1}{B_{ss}} = 11.082 \times 10^{-9} \text{ sec}$$

$$\text{Therefore, } \text{PG} = \frac{T_c}{T_e} = 704.9716$$

- synchronisation error of 30% etc,  $\Rightarrow \tau = 0.3T_{cs} = 2.34375 \mu\text{sec}$   
This indicates that  $T_c < \tau$  which implies that the o/p code-noise has:  
mean = 0  
var =  $A^2 T_c / T_{cs} = 0.68123 \text{ mW}$

$$\text{Furthermore, since } \tau > T_c \Rightarrow P_{\text{desired}} = 0 \Rightarrow \text{SNIR}_{\text{out}} = 0$$

$$\Rightarrow p_e = \mathbf{T}\{\sqrt{0}\} = 0.5$$

**ANSWER to Q4** (aim: to examine 'DS-CDMA')

- No of users = 256  $\Rightarrow$  1 desired + 255 MAI  
That is  $K = 255$
- AJM = 30dB  $\Rightarrow 10\log_{10}(\text{EUE}_{equ}) - 10\log_{10}(\text{EUE}_{equ,pr}) = 30$   
 $\Rightarrow \frac{\text{EUE}_{equ}}{\text{EUE}_{equ,pr}} = 10^3$  (Equ.1)
- 'protection'  $\text{BER} = p_{e,pr} = 10^{-2}$
- $m = 21 \Rightarrow N = 2^m - 1 = 2097161$   
 $P = 0.1915$   
 $N_0 = 10^{-6}$

$$= \frac{10^{-2}}{p_{e,pr}} = \mathbf{T}\{\sqrt{2\text{EUE}_{equ,pr}}\}$$

$$\Rightarrow \sqrt{2\text{EUE}_{equ,pr}} \simeq 2.3263$$

$$\Rightarrow \text{EUE}_{equ,pr} \simeq 2.7059$$

$$\text{This implies, using Equ 1, that } \text{EUE}_{equ} \simeq 2705.9$$

$$\text{i.e. } \frac{E_b}{N_0 + N_J} \simeq 2705.9$$

$$\Rightarrow E_b \simeq 2705.9 \left( N_0 + \left( \frac{K-1}{E_b} \right) \right) = N_J$$

$$\Rightarrow E_b \simeq \frac{2705.9 \times N_0 \times N}{N - 2705.9 \times K} = 0.0040$$

$$\cdot \quad P T_{cs} = E_b \Rightarrow T_{cs} = \frac{E_b}{P} = 21.1 \text{ msec}$$

$$N = \frac{T_{cs}}{T_c} \Rightarrow T_c = 10.042 \mu\text{sec}$$

$$\text{Therefore, PN-code rate} = \frac{1}{T_c} = 99.583 \text{ Mchips/sec}$$

- 1) by employment of three directional antennas each having  $120^\circ$  beamwidth, thereby dividing each cell into 3 sectors (Sectorisation)
- 2) by using 'voice activity' (e.g. a voice activity factor  $\alpha=0.375$ )