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

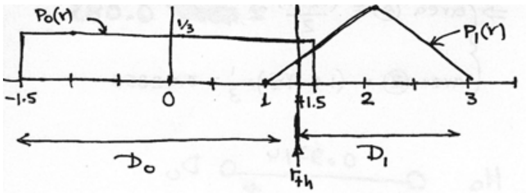
The following are provided:
- ***A table of Fourier Transforms***
- ***A "Gaussian Tail Function" grap***

Examiners responsible: Dr. A. Manikas

ANSWER to Q1

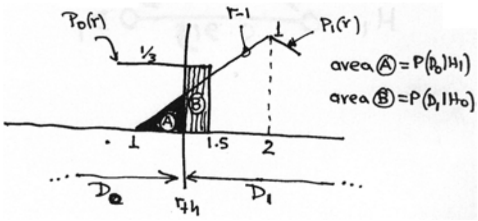
1)	A	B	C	D	E
2)	A	B	C	D	E
3)	A	B	C	D	E
4)	A	B	C	D	E
5)	A	B	C	D	E
6)	A	B	C	D	E
7)	A	B	C	D	E
8)	A	B	C	D	E
9)	A	B	C	D	E
10)	A	B	C	D	E
11)	A	B	C	D	E
12)	A	B	C	D	E
13)	A	B	C	D	E
14)	A	B	C	D	E
15)	A	B	C	D	E
16)	A	B	C	D	E
17)	A	B	C	D	E
18)	A	B	C	D	E
19)	A	B	C	D	E
20)	A	B	C	D	E

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



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

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



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

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

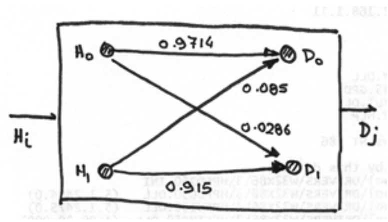
$$\Rightarrow 3-2r_{\text{th}}=r_{\text{th}}^2-2r_{\text{th}}+1$$

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

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

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

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



ANSWER to Q3 (aim: to examine 'Spread Sectrum Theory')

- $F_g = 4\,\text{kHz}$ $\quad P_J = 1.6\text{W}$
  $Q = 256\,\text{levels}$ $\quad N_0/2 = 0.5\times10^{-12}$
  $\gamma = 8\ \text{bits}$ $\quad A = 0.693\,V$
  $p_e = 3\times10^{-6}$

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- $r_{cs} = 2\times 2\gamma F_g = 2\times2\times8\times4\times10^3$ bits/sec
  $=128\times10^3\,\frac{\text{bits}}{\text{sec}}$
  $T_{cs}=\frac{1}{r_{cs}}=7.8125\,\mu$sec
- $N_0 = 10^{-12}$
- $B_J = 0.1\,B_{ss}$
- $E_b = \frac{A^2}{2}T_{cs} = 1.876\times10^{-6}$

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

  Therefore $3\times10^{-6}=\mathbf{T}\left\{\sqrt{2\text{EUE}_{equ}}\right\}$

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

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

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

  $\Rightarrow B_{ss}=\frac{P_J\times10}{-N_0+\frac{2E_b}{4.6^2}}=90.236\times10^6$
  (i.e. PN-code rate $=90.236\frac{\text{Mchips}}{\text{sec}}$)

  $\Rightarrow T_c=\frac{1}{B_{ss}}=11.082\times10^{-9}$sec

  Therefore, PG $=\frac{T_{cs}}{T_c}=704.9716$

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

  Furthermore, since $\tau > T_c \Rightarrow P_{\text{desired}}=0 \Rightarrow \text{SNIR}_{out}=0$
  $\Rightarrow p_e=\mathbf{T}\left\{\sqrt{0}\right\}=0.5$

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' $BER=p_{e,pr}=10^{-2}$

- $m=21\Rightarrow N=2^m-1=2097161$
  $P=0.1915$
  $N_0=10^{-6}$

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

  $\Rightarrow \sqrt{2\text{EUE}_{equ,pr}}\simeq2.3263$

  $\Rightarrow \text{EUE}_{equ,pr}\simeq2.7059$

  This implies, using Equ 1, that $\quad \text{EUE}_{equ}\simeq2705.9$

  i.e. $\frac{E_b}{N_0+N_J}\simeq2705.9$

  $\Rightarrow E_b\simeq2705.9\left(N_0+\underbrace{(\tfrac{K-1}{E_b})}_{=N_J}\right)$

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

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- $PT_{cs}=E_b\Rightarrow T_{cs}=\frac{E_b}{P}=21.1\,$msec

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

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

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- 1) by employment of three directional antennas each having 120° beamwidth , thereby
  diving each cell into 3 sectors (Sectorisation)
  2) by using 'voice activity' (e.g. a voice activity factor α=0.375)