UNIVERSITY OF LONDON **[MSc-C2, E401, I411]**
IMPERIAL COLLEGE OF SCIENCE TECHNOLOGY AND MEDICINE

DEPARTMENT of ELECTRICAL and ELECTRONIC ENGINEERING
EXAMINATIONS 2001
M.Sc in Communications and Signal Processing
M.Eng. Part IV

ADVANCED COMMUNICATION THEORY

— There are FOUR questions (Q1 to Q4)
— Answer question Q1 plus 2 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.

The following are provided:

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

Examiners responsible: Dr. A. Manikas

Question-2

a) Consider a binary communication model in which one of two <u>known</u> signals $s_0(t)$ or $s_1(t)$ is received in the time interval (0,T) in the presence of bandlimited additive white Gaussian noise of power-spectral-density $PSD_n(f)=\frac{N_0}{2}\ \mathrm{rect}\left\{\frac{f}{2B}\right\}$.
If a correlation receiver is used, estimate the probability of error, p_e, as a function of λ_0, EUE, and ρ and the a priori probabilities $\Pr(\mathrm{H}_0), \Pr(\mathrm{H}_1)$ **(40%)**

where $\begin{cases} \lambda_0 & \text{is the likelihood ratio threshold defined by the chosen decision criterion,} \\ \text{EUE} & \text{is the Energy-Utilization-Efficiency of the system, and} \\ \rho & \text{is the time cross-correlation between signals.} \end{cases}$

N.B.:
A correlation receiver is based on the **Decision Rule**:

$$\text{choose } \mathrm{H}_1 \ \ \textit{if } G > r_{threshold} \ \ \textit{where} \begin{cases} G = \int_0^{T_{cs}} r(t)\, s_1(t)\, dt - \int_0^{T_{cs}} r(t)\, s_0(t)\, dt \\ r_{threshold} \equiv \frac{N_0}{2} \ln(\lambda_0) + \frac{1}{2}\int_0^{T_{cs}} \left(s_1(t)^2 - s_0(t)^2\right) dt \end{cases}$$

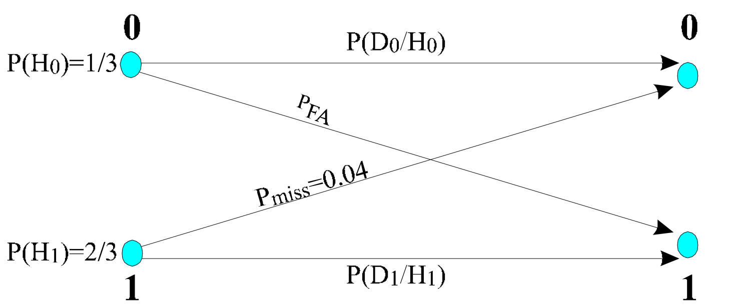
otherwise, choose H_0

where $r(t)$ represents the received signal.

b) Consider a binary communication system in which the channel noise is additive Gaussian of zero mean and variance 1, that is N(0,1). The system employs two correlated signals with cross-correlation coefficient ρ, and a correlation receiver which operates on the Bayes-decision criterion with the following costs:

$C_{00}=C_{11}=0$; $C_{10}=1.858$; $C_{01}=0.5$.

If the communication system has an energy utilisation efficiency $\text{EUE} = 5.25 \times 10^{-2}$ and is modelled as follows:



estimate the cross correlation coefficient ρ. **(40%)**

What is the False Alarm Probability, $\mathrm{P_{FA}}$, and the bit error probabilty, P_e, for the above system? **(20%)**

Question-3

a) Consider an m-sequence waveform $b(t)$ of period NT_c with $R_{b,M}(\tau)$ denoting its partial autorrelation function over MT_c with $M < N$,

$$\text{i.e.} \quad R_{b,M}(\tau) = \frac{1}{MT_c}\int_0^{MT_c} b(t).b(t-\tau).dt$$

Plot the mean and the variance of $R_{b,M}(\tau)$ for $-NT_c < \tau < NT_c$. **(20%)**

b) A BPSK direct sequence spread spectrum system (BPSK/DS-SSS) has a PN-code rate of 10 Mchips per second and a binary message rate of 1000 bits per second. The EUE at the receiver's input is 100 and the double-sided power spectral density of the received noise is 0.5×10^{-8} Watts per Hz. For this system, in which the correlation time is exactly one message bit, what would be the receiver's synchronization errors (τ, θ) which would provide code noise power equal to 3.75×10^{-8}W, knowing that if $\tau > T_c$ then the code noise is constant and equal to 1.5×10^{-7}W. **(80%)**

N.B.: τ represents the PN-code time error and θ denotes the carrier's phase error.

Question-4

Consider an M-ary Communication System with its signal set described as follows:

$$s_i(t) = A_i \boldsymbol{\Lambda}\left\{\frac{2t}{T_{cs}}\right\}, \; i = 1, 2, .., M.$$

$$\text{with} \begin{cases} M = 4 \\ A_i = (2i - 1 - M) \times 10^{-3}\text{Volts} \\ T_{cs} = 12\,\text{sec} \\ \Pr(\text{H}_1) = \Pr(\text{H}_4) = 1/8 \;\text{ and } \Pr(\text{H}_2) = \Pr(\text{H}_3) = 3/8 \end{cases}$$

The signals are transmitted over a communication channel which adds white Gaussian noise having a double-sided power spectral density of 10^{-6} W/Hz.

a) Find and plot the power spectral density of the transmitted signal $s(t)$. **(20%)**

b) Calculate the values of the signal-vectors $\underline{w}_{s_i}$, $i = 1, 2, 3, 4$ for the above signal-set. **(20%)**

c) Draw a labelled block diagram of the MAP correlation receiver, based on the signals vectors $\underline{w}_{s_i}$, $i =$ 1,2,3,4. **(20%)**

d) plot the constellation diagram and label the decision regions. **(25%)**

e) Find the symbol error probability $p_{e,cs}$ at the output of MAP receiver. **(15%)**

[END]