OLLSCOIL NA hÉIREANN
THE NATIONAL UNIVERSITY OF IRELAND

COLÁISTE NA hOLLSCOILE, CORCAIGH
UNIVERSITY COLLEGE, CORK

SUMMER EXAMINATIONS, 2002

B.E. DEGREE (ELECTRICAL)

TELECOMMUNICATIONS
EE4004

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[Use of the approved electronic calculator is permitted.]

Time allowed; *3 hours*

Answer *six* questions.
(All questions carry equal marks.)

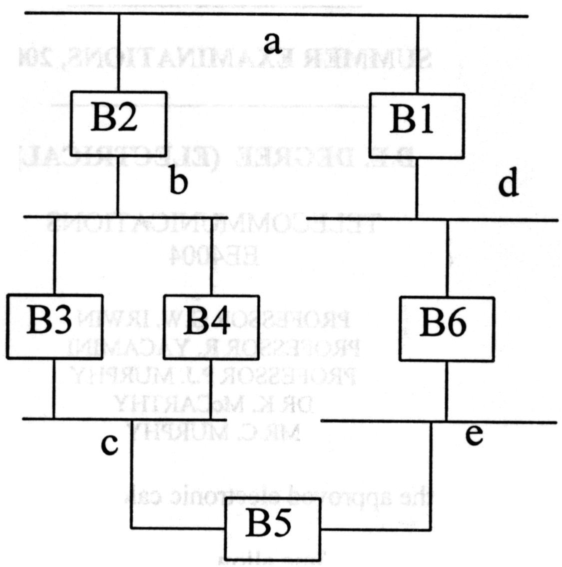
1. Derive the relationship between quantisation noise and the number of quantisation levels in pulse code modulation telephony systems.
A PCM-TDM system is to handle three video signals each band limited to 5.5 MHz. The signals are sampled at the minimum rate and signal to quantisation noise level must be at least 53 dB. If one bit per word is used for synchronisation, and 8-QAM is used for transmission, what is the rate of phase change of the carrier?

2. (a) Discuss the use of *line codes* in PCM systems and, hence, explain the use of the HDB3 code.

(b) (i) Illustrate the make-up of an ATM frame which is used at a network-network interface and specify the main functions of the fields you identify in the frame.
(ii) Draw the error handling state diagram used by ATM and from this explain the handling of single bit and burst errors.

3. (a) Explain the concept of *transparent routing* when interconnecting LANs and illustrate how this may give rise to *loops* using an appropriate diagram.

(b) Explain the spanning tree algorithm which is used to find the shortest paths in a set of interconnected LANs. Apply this algorithm to the network below and illustrate the resulting shortest paths by redrawing the diagram in your answer books with the shortest paths highlighted. The bridges are labelled B1 to B6 corresponding to I.D. numbers 1 to 6 respectively. These bridges interconnect the five LANs (a to e) as shown.



4. For the general communications channel model illustrated overleaf show that if: -

$$\beta_1 = p(1-e_1-e_2)+e_2 \quad \text{and} \quad \beta_2 = p(e_1+e_2-1)+1-e_2$$

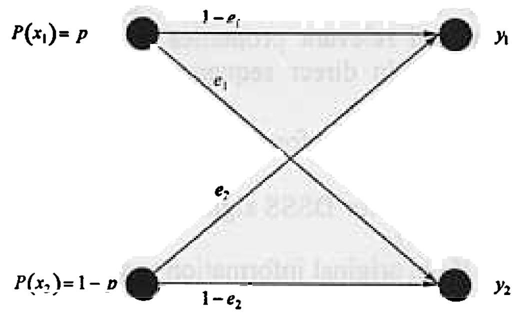
then: -

(i) $H(Y) = -Log_2\left[\beta_1^{\beta_1}\beta_2^{\beta_2}\right.$

(ii)

$$I(X;Y) = Log_2\left[\frac{\left((1-e_1)^{1-e_1}e_1^{e_1}\right)^p\left((1-e_2)^{1-e_2}e_2^{e_2}\right)^{1-p}}{\beta_1^{\beta_1}\beta_2^{\beta_2}}\right]$$

(iii) Hence, or otherwise, for the particular case of a binary symmetric channel with equiprobable input symbols, deduce the appropriate expression for the mutual information $I(X;Y)$.



General communications channel model.

5. (i) For a parity-check linear block code, show that the syndrome $\underline{s}$ is the sum (modulo 2) of those rows of the matrix $\underline{H}^T$ corresponding to the error locations in the error pattern.

(ii) A parity-check linear block code has the parity-check matrix: -

$$\underline{H}=\begin{bmatrix} & 0 & 1 & & 0 & 0 \\ & 1 & 0 & 0 & 1 & 0 \\ 0 & 1 & 1 & 0 & 0 & 1 \end{bmatrix}.$$

Suppose that the received word is 110110. Decode this received word.
Prove that this parity-check linear block code can reliably correct no more than 1 error.

6. A binary modulation scheme is described by:

$$s_i(t)= \begin{matrix} s_1(t)=A_1 Cos[\omega_c t] & \quad 0\le t\le T \\ s_2(t)=A_2 Cos[\omega_c t] & \quad 0\le t\le T \end{matrix}$$

where T is an integer times $1/f_c$. For this modulation scheme, given that (under the usual assumptions) $P_e = Q\left[\sqrt{\frac{E_d}{2\eta}}\right]$, show that: -

(i) $P_e = Q\left[\sqrt{\frac{(A_1-A_2)^2 T}{4\eta}}\right]$.

(ii) If the average signal energy per bit (denoted E_b) is a fixed constant, prove that P_e in (i) above is minimized if $A_2 = -A_1$.
Hint: - the minimum value of $Q\left[\sqrt{x}\right]$ occurs when x takes on its maximum possible value.

7. (i) With the aid of suitable diagrams, describe the hardware implementation and relevant properties of m-sequence spreading codes as employed in direct sequence spread spectrum (DSSS) communication systems.

Derive a suitable expression for the probability of error (denoted P_e where $P_e = Q\left[\sqrt{\frac{E_d}{2\eta}}\right]$) for DSSS signals in additive white Gaussian noise channels if the original information sequence is represented by a simple bipolar baseband signal.

With the aid of suitable diagrams, illustrate the application of spread spectrum techniques in the Global Positioning System (GPS).