OLLSCOIL NA hÉIREANN
THE NATIONAL UNIVERSITY OF IRELAND

COLÁISTE NA hOLLSCOILE, CORCAIGH
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AUTUMN 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. Compare the capacities of BPSK, QPSK, and QAM systems and discuss the factors which influence the choice of a particular modulation scheme.
A microwave link using 64 QAM modulation is used to carry three signals of 5 MHz, 10 MHz and 15 MHz bandwidth respectively, which have been encoded using PCM. If the carrier modulation rate is 6×10^7 phase changes per second, what is the maximum possible signal to quantisation noise ratio in dB?

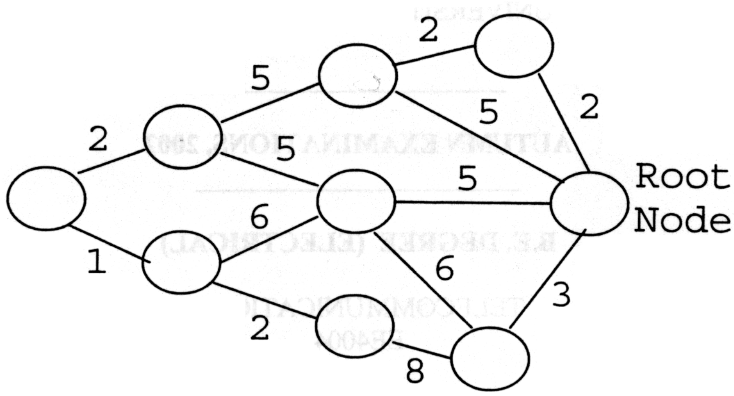
2. (a) Contrast the operation of time division multiple access (TDMA) techniques in satellite and mobile communications systems.

(b) List the layers of the OSI model of a communications system in their usual order and briefly describe the function of each layer.

3. (a) Illustrate the format of an IP (Internet Protocol) packet and state the function of each field in the packet.

Question 3(b) is continued over/.

(b) Describe the Bellman-Ford algorithm used for internet routing and apply the algorithm to determine the shortest paths from each node to the root node of the network below where the distances are indicated on each link:



4. A channel has the following channel matrix: -

$$[P(Y|X)] = \begin{bmatrix} 1-p & p & 0 \\ 0 & p & 1-p \end{bmatrix}.$$

The source X emits 2 symbols, denoted x_1, x_2 where $P(x_1) = \alpha$

(a) Draw the channel diagram.

(b) Show that:

(i) $$H(Y) = (1-p)(-\alpha Log_2[\alpha] - (1-\alpha)Log_2(1-\alpha)) - pLog_2[p] - (1-p)Log_2[1-p].$$

(ii) $$H(Y|X) = -pLog_2[p] - (1-p)Log_2[1-p]$$

(iii) The channel capacity C_s (bits/symbol) is given by $C_s = 1-p$

5. For a $(6,3)$ systematic linear block code, the three parity-check bits c_4, c_5 and c_6 are formed via:

$$c_4 = d_1 \oplus d_3$$
$$c_5 = d_1 \oplus d_2 \oplus d_3$$
$$c_6 = d_1 \oplus d_2.$$

(a) Determine the generator matrix G.

(b) Construct all possible code words.

(c) Suppose the received word is 010111. Decode this received word by finding the location of the error and the transmitted bits.

(d) Prove that $d_{\min} = 3$ and that the code can correct a single error.

6. (a) A binary communication system subject to additive white Gaussian noise (of zero mean and variance σ^2) uses the following signals: -

$$s_i(t) = \begin{cases} s_1(t) = 0 & 0 \le t \le T \quad \textit{for logic 0} \\ s_2(t) = A & 0 \le t \le T \quad \textit{for logic 1.} \end{cases}$$

If the receiver takes one sample during the transmission interval and compares it with a threshold value T, show that the value of T minimizing the probability of error is given by: -

$$T = \frac{A}{2} + \frac{\sigma^2}{A} \ln\left[\frac{P_0}{P_1}\right]$$

where P_0 denotes the probability of sending logic 0 and P_1 denotes the probability of sending logic 1.

(b) If the system described in part (a) above has the following characteristics:

$A = \ \ V \qquad \sigma^2 = 0.1\ W \qquad T = 0.65\ V$

determine the entropy of the source.

7. (a) With the aid of suitable diagrams, describe the principle features and strengths/weaknesses of direct sequence spread spectrum (DSSS) systems.

(b) Two DSSS systems, denoted A and B, possess the same probability of error (i.e. $P_e = Q\left[\sqrt{\frac{E_d}{2\eta}}\right]$) in an additive white Gaussian noise channel. The original information sequences are respectively represented by: -

System A **System B**

$$s_i(t) = \begin{cases} s_1(t) = A_1 & 0 \le t \le T \\ s_2(t) = 0 & 0 \le t \le T \end{cases} \qquad s_i(t) = \begin{cases} s_1(t) = A_2 & 0 \le t \le T \\ s_2(t) = -A_2 & 0 \le t \le T. \end{cases}$$

Prove that the average signal energy per bit required by system A is twice that of system B.