OLLSCOIL NA hÉIREANN, CORCAIGH
THE NATIONAL UNIVERSITY OF IRELAND, CORK

COLÁISTE NA hOLLSCOILE, CORCAIGH
UNIVERSITY COLLEGE, CORK

SUMMER EXAMINATIONS, 2003

B.E. DEGREE (ELECTRICAL)

TELECOMMUNICATIONS
EE4004

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Time allowed: *3 hours*

Answer *six* questions.

The use of a Casio fx570w or fx570ms calculator is permitted.

1. (a) Discuss the use of adaptive schemes in digital modulation systems.

[*6 marks*]

(b) The capacity of a digital microwave radio link is to be increased by changing the modulation scheme from 8-PSK to 64-QAM. If the existing capacity of the system (using Nyquist sampling rate) is three 6 MHz uncompressed video channels with a signal to quantisation noise level better than 43 dB, how many video channels may be carried in the new system if the S/N is to be better than 50 dB and a video compression ratio of 3:1 is also implemented?

[*10 marks*]

2. (a) Describe and discuss the modifications necessary to upgrade a GSM network to GPRS operation.

[*7 marks*]

(b) (i) Illustrate the timing of the packet and acknowledgement transfers for a data-link which uses a "go-back-N" ARQ scheme and, from this, determine an expression for the utilization, U, of the data-link.

[6 *marks*]

(ii) For a 100 km data-link with a data rate of 155 Mbps, determine the minimum frame window, N, which is needed to guarantee a utilization of 100% assuming an error-free line. The packet size is 2500 bits, the acknowledgement size is 100 bits and the propagation delay is 5 μs/km.

[*4 marks*]

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

[*4 marks*]

(b) A company uses TCP/IP for networking. It has two Ethernet LANs which are interconnected by means of a router, R1. R1 is linked to a second router, R2, which is the point-of-presence for internet access. The internet addresses of the computers on the two LANs are of the form LAN1.* and LAN2.*. Computer A is on LAN1, computer B is on LAN2 and computer C is an external computer linked to the internet.

(i) Describe the sequence of data transfers which occur when computer A sends data to computer B.

[*6 marks*]

(ii) Describe the sequence of data transfers which occur when computer A sends data to computer C.

[*7 marks*]

4. (a) Show that the mutual information $I(X;Y)$ for the binary symmetric channel (BSC) with equiprobable inputs x_1 and x_2, probability of error p and outputs y_1 and y_2 is given by: -

$$I(X;Y) = 1 + p\log_2(p) + (1-p)\log_2(1-p).$$

[*6 marks*]

(b) The outputs of the BSC in (a) above are connected to the inputs of another BSC with probability of error p and outputs z_1 and z_2.

(i) Develop the composite channel diagram relating inputs x_1 and x_2 to outputs z_1 and z_2. [*3 marks*]

(ii) If $p = 0.1$, determine the values of $I(X;Y)$ and $I(X;Z)$ and comment upon your result. [*7 marks*]

5. (a) With the aid of appropriate mathematical relationships, describe the process of error correction via syndrome decoding in a linear block code.

[*9 marks*]

(b) Consider a single-error-correcting linear block code for 10 data bits.

(i) How many parity check bits are required? [*2 marks*]

(ii) Find a parity check matrix H for this code. [*2 marks*]

(iii) Illustrate the failure of the code specified in (ii) above to correct 2 errors. [*3 marks*]

6. (a) Given that the output signal to noise ratio (SNR) of a matched filter receiver subject to additive white Gaussian noise (AWGN) with power spectral density $\eta/2\ W/Hz$ is given by $2E_d/\eta$ where E_d denotes the energy in the difference signal, show that the optimum output SNR is given by: -

$$\left(\frac{S}{N}\right)_{Optimum} = \frac{8E}{\eta}$$

where we stipulate that the signaling waveforms $s_1(t)$ and $s_2(t)$ must have the same signal energy E.

[*7 marks*]

(b) A frequency shift keying modulation scheme is defined by: -

$$s_i(t) = \begin{cases} A\cos(\omega_1 t) & 0 \le t \le T_f \\ A\cos(\omega_2 t) & 0 \le t \le T_f. \end{cases}$$

Show that if $\omega_1 T_f >> 1$, $\omega_2 T_f >> 1$ and $(\omega_1 - \omega_2)T_f >> 1$ then the probability of error P_e when subject to AWGN with power spectral density $\eta/2\ W/Hz$ and optimum matched filtering detection is used is approximated by: -

$$P_e \approx Q\left[\sqrt{\frac{A^2 T_f}{2\eta}}\right].$$

[*6 marks*]

(c) A phase shift keying modulation scheme is defined by: -

$$s_i(t) = \begin{cases} A\cos(\omega_1 t) & 0 \le t \le T_\phi \\ -A\cos(\omega_1 t) & 0 \le t \le T_\phi. \end{cases}$$

where T_ϕ is an integer times $1/f_1$ (where $\omega_1 = 2\pi f_1$). If, under the same conditions as (b) above, this scheme must possess the same probability of error P_e as that of (b) above, deduce the value of T_f/T_ϕ and comment upon your result.

[*4 marks*]

7. (a) An analogue signal having an 8-kHz bandwidth is sampled at 1.25 times the Nyquist rate and each sample is quantised into one of 128 equally likely levels (you may assume successive samples are statistically independent). Estimate via the use of a suitable graph, or otherwise, the minimum channel bandwidth required for error-free transmission of the information produced by this source if the signal power at the receiver is 0.1mW and the communication is affected by additive white Gaussian noise with power spectral density $\eta/2 = 10^{-12}\, W/Hz$.

[7 *marks*]

(b) Summarise the principle characteristics of spread spectrum communications.

[*10 marks*]