OLLSCOIL NA h-ÉIREANN
THE NATIONAL UNIVERSITY OF IRELAND CORK

COLÁISTE NA h-OLLSCOILE, CORCAIGH
UNIVERSITY COLLEGE CORK

SUMMER EXAMINATIONS 2001

B.E. DEGREE (ELECTRICAL)

TELECOMMUNICATIONS (EE4004)

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The use of the approved electronic calculator is permitted.

3 Hours

ANSWER SIX QUESTIONS

Q.1. Compare the transmission capacities of BPSK, QPSK, and QAM systems and discuss the factors which influence the choice of 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 Pulse Code Modulation.

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? What would be the effect of upgrading the link to 128 QAM?

Q.2. (a) Briefly discuss Frame Relay and ATM networks for fast packet switching mentioning the frame formats, congestion control and acknowledgement handling used.

(b) Illustrate briefly how ATM links achieve synchronization using the HEC.

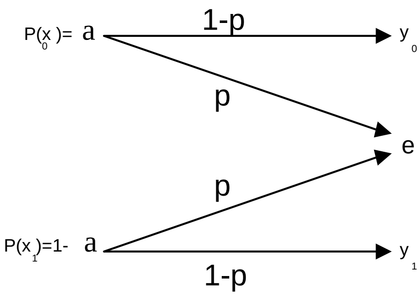
(c) A communications system uses frames which have header and data sections. The data section can have a length of either 32 bytes or 64 bytes. Which length would be preferable to (i) the telephony industry and (ii) the data communications industry and why?

Q.3. For digital subscribed line (DSL) technologies discuss the following:

(a) The signal duplexing methods available.
(b) The main sources of interference.
(c) The DMT and CAP modulation schemes used.

Q.4. The channel diagram shown below represents the "binary erasure channel". The output $y_2 = e$ indicates an "erasure"; that is, the output is in doubt and should be erased. Show that if we consider Y to be a source generating symbols y_1, e and y_2 with probabilities appropriate to the channel diagram then: -

(a) $H(Y) = (1-p)((\alpha-1)Log_2[1-\alpha] - \alpha Log_2[\alpha] - Log_2[1-p]) - pLog_2[p]$.
(b) $H(Y|X) = -p\,Log_2[p] - (1-p)Log_2[1-p]$
(c) The channel capacity $C_s = 1-p$.



Binary erasure channel diagram.

Q.5. Typical expressions for *ASK* and *PSK* modulated waveforms representing binary data, where in each case T is an integer times $1/f_c$, are as follows: -

ASK

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

PSK

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

In addition, the probability of error for a binary modulation scheme (denoted by *MOD*) with optimum detection in the presence of AWGN with a power spectral density of $\eta/2 W/Hz$ is given by $P_e^{MOD} = Q\left[\sqrt{\frac{E_d}{2\eta}}\right]$ where E_d denotes the energy in the appropriate difference signal (over a single bit interval).

(a) Derive expressions for P_e^{ASK} and P_e^{PSK}.

(b) If the average signal enery per bit for the ASK and PSK modulation schemes above is made **equal**, derive the following expression for the enhancement in reliability, denoted E, achieved by choosing PSK over ASK when both schemes deliver the same bit rate: -

$$E = \frac{P_e^{ASK}}{P_e^{PSK}} = \frac{Q\left[\sqrt{\frac{A_2{}^2 T}{2\eta}}\right]}{Q\left[\sqrt{\frac{A_2{}^2 T}{\eta}}\right]}.$$

(c) By using the table of values of $Q[x]$ provided to draw a suitable graph, or otherwise, estimate the amplitude A_2 resulting in $E = 45$ when $\eta/2 = 10^{-12} W / Hz$ and the bit rate is 1 Mb/s.

Q.6. (a) Show that an (n,k) single error correcting perfect linear block code possesses the following relationship between n and k : -

$$k = n - Log_2[n+1].$$

(b) Design a single error correcting perfect linear block code to protect 4 data bits and demonstrate the encoding procedure by encoding the binary string 1010.

(c) Illustrate the capability of your code to correct a single error in a received sequence.

Q.7. (a) With the aid of a diagram and relevant supporting mathematics, describe the operation of a cyclic redundancy check (CRC) encoder.

(b) For a particular CRC encoder the generating polynomial is given by $G(x) = x^{15} + x^{12} + x^5 + 1$. Illustrate the error detection capabilities of this CRC based system by encoding the message string $M(x) = x^8 + x^7 + x^4 + x^2 + 1$, introducing an error in the *MSB* of the **transmitted** sequence and performing the appropriate calculations.