OLLSCOIL NA hÉIREANN
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AUTUMN EXAMINATIONS, 2001

B.E. DEGREE (ELECTRICAL)

TELECOMMUNICATIONS
EE4004

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[The use of *non-programmable* calculators is permitted.

Time allowed; *3 hours*

Answer *six* questions.

Contrast the operation of time division multiple access (TDMA) techniques in satellite and mobile communications systems.
A PCM-TDM system is to handle four video signals each band limited to 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 QPSK is used for transmission, what is the rate of phase change of the carrier?

Q2 (a) List the layers of the OSI model of a communications system in their usual order and describe briefly the function of each layer in the model.
(b) Outline the different types of switching which can be used to route information through a Wide Area Network.
(c) Illustrate the format of an X.25 packet.

Q3 For Asymmetric Digital Subscriber Line (ADSL) technologies discuss the following:

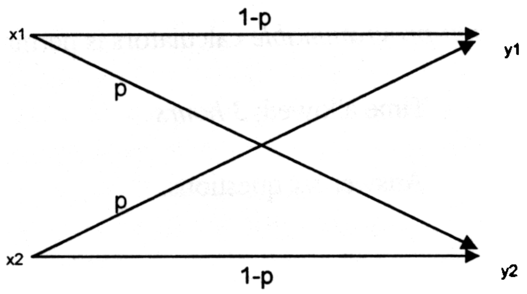
(a) The main sources of noise and cross-talk which degrade the signals.
(b) The allocation of the frequency spectrum between voice and data communications.
(c) The main modulation methods used for transporting the data signals.

Q.4. For the binary symmetric channel shown below prove that if $P(x1) = \alpha$ and $P(x2) = 1 - \alpha$ then -

(i) $I(X;Y) = -\alpha Log_2[\alpha] - (1-\alpha)Log_2[1-\alpha] - (pLog_2[p] + (1-p)Log_2[1-p])$

(ii) The channel capacity C_S is given by: -

$$C_S = 1 - Log_2\left[p^p(1-p)^{1-p}\right].$$



Q.5. A system transmitting binary data uses 0 volts to represent logic 0 and A volts to represent logic 1. Let P_0 and P_1 denote the probabilities of sending logic 0 and logic 1 respectively and note that the pdf of a Gaussian random variable with mean m and standard deviation σ is given by: -

$$p(v) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{\frac{-(v-m)^2}{2\sigma^2}}.$$

If the system is affected by additive white Gaussian noise of mean value 0 volts and standard deviation σ volts show that: -

(i) The optimum decision threshold T in the receiver is given by: -

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

(ii) For an equiprobable source the total probability of error P_e is given by: -

$$P_e = \frac{1}{2} - \frac{1}{\sqrt{2\pi\sigma^2}} \int_0^{A/2} e^{-\frac{v^2}{2\sigma^2}} dv.$$

Q.6. It is required to transmit 2.08 Mb/s with an error probability of $P_e \leq 10^{-6}$. The channel noise is white with a power spectal density of $\eta/2 = 10^{-11} W/Hz$. With the aid of the table of values of $Q[z]$ attached, (see page 4), determine the signal power required at the receiver input using: -

(i) Unipolar baseband signaling: -

$$s_i(t) = \begin{cases} s_1(t) = A_1 & 0 \leq t \leq T \\ s_2(t) = 0 & 0 \leq t \leq T. \end{cases}$$

(ii) Bipolar signaling: -

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

Q.7. A system uses an (n,k) linear block code to protect data from up to and including t errors during transmission. If the probability of a binary transmission error is denoted P_e (i.e. the probability of deciding logic 1 was sent when in fact logic 0 was sent, and vice-versa): -

(i) Show that the probability that the output of an (n,k) linear block code decoder will be correct is given by: -

$$P_{correct} = \sum_{i=0}^{t} \binom{n}{i} (1 - P_e)^{n-i} P_e^i$$

(ii) If the binary modulation scheme is designed in such a way that $P_e = 10^{-5}$, estimate the probability that the output of a $(7,4)$ Hamming code decoder is **<u>not</u>** correct.

Table of Values of $Q(z)$

z	$Q(z)$	z	$Q(z)$	z	$Q(z)$
0	0.5	1.7	0.0445655	3.4	0.000336929
0.05	0.480061	1.75	0.0400592	3.45	0.000280293
0.1	0.460172	1.8	0.0359303	3.5	0.000232629
0.15	0.440382	1.85	0.0321568	3.55	0.000192616
0.2	0.42074	1.9	0.0287166	3.6	0.000159109
0.25	0.401294	1.95	0.0255881	3.65	0.00013112
0.3	0.382089	2.	0.0227501	3.7	0.0001078
0.35	0.363169	2.05	0.0201822	3.75	0.0000884173
0.4	0.344578	2.1	0.0178644	3.8	0.000072348
0.45	0.326355	2.15	0.0157776	3.85	0.0000590589
0.5	0.308538	2.2	0.0139034	3.9	0.0000480963
0.55	0.29116	2.25	0.0122245	3.95	0.0000390756
0.6	0.274253	2.3	0.0107241	4.	0.0000316712
0.65	0.257846	2.35	0.00938671	4.25	10^{-5}
0.7	0.241964	2.4	0.00819754	4.75	10^{-6}
0.75	0.226627	2.45	0.00714281	5.2	10^{-7}
0.8	0.211855	2.5	0.00620967		
0.85	0.197663	2.55	0.00538615		
0.9	0.18406	2.6	0.00466119		
0.95	0.171056	2.65	0.00402459		
1.	0.158655	2.7	0.00346697		
1.05	0.146859	2.75	0.00297976		
1.1	0.135666	2.8	0.00255513		
1.15	0.125072	2.85	0.00218596		
1.2	0.11507	2.9	0.00186581		
1.25	0.10565	2.95	0.00158887		
1.3	0.0968005	3.	0.0013499		
1.35	0.088508	3.05	0.00114421		
1.4	0.0807567	3.1	0.000967603		
1.45	0.0735293	3.15	0.000816352		
1.5	0.0668072	3.2	0.000687138		
1.55	0.0605708	3.25	0.000577025		
1.6	0.0547993	3.3	0.000483424		
1.65	0.0494715	3.35	0.000404058		