Data Provided: None

The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Autumn Semester 2013-2014 (2 hours)

Communication Principles

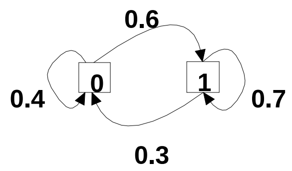
Answer **THREE** questions. **No marks will be awarded for solutions to a fourth question.** Solutions will be considered in the order that they are presented in the answer book. Trial answers will be ignored if they are clearly crossed out. **The numbers given after each section of a question indicate the relative weighting of that section.**

1. a. What is information and entropy? With the aid of an example, explain on which condition a source will reach its maximum entropy. **(8)**

b. A signal fed into a uniform quantiser has its values uniformly distributed over the range from -2V to 2V. Suppose the quantiser has 64 equally spaced quantile levels covering the full range of the input signal. Determine the quantisation noise power and the quantisation noise-to-signal power ratio. **(6)**

c. What is the Shannon limit on the minimum bit energy per noise density ($\frac{E_b}{N_o}$) below which there is no error-free communication? Derive the expression for this limit and show all working. **(6)**

2. **a.** A particular information source can be represented by the following Markov model:



(i) Determine the entropy of this source. (6 marks)

(ii) Since this is a source with memory, a more efficient coding scheme can be developed to represent it. Determine such a unique, prefix-free coding scheme. (4 marks)

(iii) What is the compression ratio for this coding scheme? (2 marks) **(12)**

b. A linear block coding system uses the following codes to send eight different messages:

0000	1001	1010	0011
1100	0101	0110	1111

(i) How many bit errors per code word can be detected at the receiver? (2 marks)

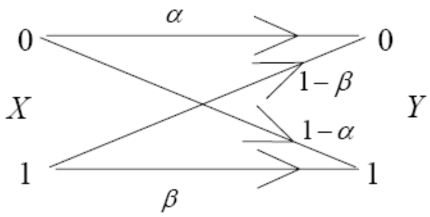
(ii) Is forward error correction possible with this code? (1 mark)

(iii) Calculate the code rate for this code. (1 mark) **(4)**

c. What is Additive White Gaussian Noise (AWGN) and why it is a suitable model for noise in many situations? **(4)**

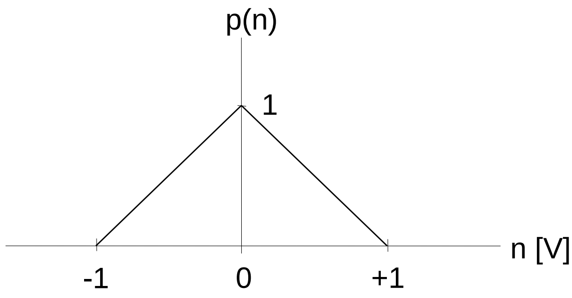
3. **a.** Explain the three levels of synchronisation used in a digital communication system. **(6)**

b. Two binary channels are connected in cascade (the output of the first channel is fed to the input of the second channel). Find the overall error probability of the cascaded connection, assuming that both channels have the same transition probability as shown below. P(0)=0.4, P(1)=0.6, $\alpha = 0.9$ and $\beta = 0.8$.



(4)

c. A ternary system sends one of three different symbols, S_1, S_2 and S_3, with equal *a priori* probabilities, using the voltages –1.6V, 0V and +1.6V, respectively. The transmission channel is subject to additive noise with a triangular distribution as shown in the following figure.



Noise probability density function.

(i) Assume there is no attenuation along the channel. Determine the decision rule for a maximum likelihood detector. (3 marks)

(ii) What is the overall probability of error using the above detector? (5 marks)

(iii) If a Maximum A Posteriori (MAP) detector is used and the *a priori* probability of S_2 increases to nearly 1, i.e. $P(S_2) \rightarrow 1$, and $P(S_1)$, $P(S_3) \rightarrow 0$, what will change to the decision rule of (i)? What is the probability of error in this case? (2 marks) **(10)**

4. **a.** Suppose a particular multiple access channel supports a total data rate of R bits/s, and there are M users, calculate the message delays involved for a transmission period of T seconds in a FDMA system and a TDMA system, respectively. **(5)**

b (i) Configure a (4,3) odd-parity error-detection code such that the parity symbol appears as the leftmost symbol of the codeword. (1 mark)

(ii) Which error patterns can the code detect? (1 mark)

(iii) Calculate the probability of an undetected message error, assuming that all symbol errors are independent and that the probability of a channel symbol error is p=0.001. (3 marks) **(5)**

c. In a spread spectrum system the information is transmitted using a much wider bandwidth than required for the baseband data and to achieve this, Pseudo-Noise (PN) sequences are employed as the spread code.

(i) State the basic properties that can be applied to test the randomness of a PN sequence. (3 marks)

(ii) Give an example of a circuit that can be used to generate a PN sequence. (2 marks) **(5)**

d. Alice operates a public key encryption system that uses the RSA algorithm with e = 3, d = 7, N = 33. Assuming that Alice and Bob have never previously met or communicated with each other, explain each of the steps required to send the message M = 15 from Bob to Alice without anyone else being able to intercept it. **(5)**

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