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Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

B.Tech Degree S7 (S, FE) / S7 (PT) (S,FE) Examination December 2023 (2015 Scheme)

Course Code: EC401

Course Name: INFORMATION THEORY & CODING

Max. Marks: 100 Duration: 3 Hours

PART A

Answer any two full questions, each carries 15 marks. Marks

1 a) A continuous signal is bandlimited to 10 kHz. The signal is quantized in 8 levels of a PCM system with probabilities 0.25, 0.2, 0.2, 0.1, 0.1, 0.05, 0.05, and 0.05. Calculate the entropy and the rate of information. (5)

b) Prove that mutual information is always non-negative. (5)

c) Consider a channel with a transition matrix, (5)

$$P(Y/X) = \begin{bmatrix} 2/3 & 1/3 \\ 1/3 & 2/3 \end{bmatrix}$$

Identify the type of channel and draw the channel diagram.

2 a) Determine the different entropies H(X), H(Y), H(X, Y), H(X|Y), and H(Y|X) for the Joint Probability Matrix given below. Also, verify the relationship between different entropies. (10)

$$P(X,Y) = \begin{bmatrix} 0.3 & 0.05 & 0 \\ 0 & 0.25 & 0 \\ 0 & 0.15 & 0.05 \\ 0 & 0.05 & 0.15 \end{bmatrix}$$

b) Write the positive and negative statements of Shannon's channel coding theorem. (5)

3 a) Consider a set of message symbols S = {s1, s2, s3, s4, s5} with probabilities P = {0.25, 0.25, 0.2, 0.15, 0.15}. Construct a binary code using the Shannon–Fano coding procedure and determine the code efficiency. (6)

b) Derive the capacity of binary erasure channel with the help of channel diagram. (6)

c) For a DMS source with 2 symbols, if one of the symbol probabilities is α, then determine the entropy of the source. Also plot the entropy graph for different values of α. (3)

PART B

Answer any two full questions, each carries 15 marks.

4 a) Given an AWGN channel with 4 kHz bandwidth and the noise power spectral density $N_0/2 = 10^{-9}$ W/Hz. The signal power required at the receiver is 0.1 mW. Calculate the capacity of this channel. (6)

b) For a systematic linear block code whose generator matrix is given below, (9)

$$G = \begin{bmatrix} 1 & 0 & 0 & 0 & 1 & 1 \\ 0 & 1 & 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 1 & 1 & 0 \end{bmatrix}$$

Find the error detecting and correcting capabilities of the code. Also draw the syndrome computation circuit.

5 a) Derive the expression for differential entropy of a Gaussian distributed random variable with zero mean and variance σ^2. (8)

b) For a systematic (7,4) linear block code, the sub-matrix P is given by (7)

$$P = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 1 \end{bmatrix}$$

Find the generator and parity check matrix of the code. Determine the code vectors corresponding to the message vectors [0010] and [1010].

6 a) Consider the following generator matrix over GF(2) for a linear block code. (8)

$$G = \begin{bmatrix} 1 & 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 1 & 1 \\ 0 & 1 & 0 & 1 & 0 \end{bmatrix}$$

Construct the standard array for this code.

b) With the help of graph, explain the SNR trade off graph of Gaussian channel. (7)

PART C

Answer any two full questions, each carries 20 marks.

7 a) Consider a convolution encoder, given rate 1/3, constraint length L = 3. Given $g^{(1)}$ = (1 0 0), $g^{(2)}$ = (1 0 1), $g^{(3)}$ = (1 1 1). Obtain the codeword sequence corresponding to the information sequence (11001). (8)

b) Explain the construction of generator matrix and parity check matrix of systematic and non-systematic Hamming code with the help of an example. (7)

c) What are the features of Reed-Solomon codes? (5)

8 a) Draw a (2,1,2) convolutional encoder with the feedback polynomials as $g^{(1)}(D)$ = (10)

$1+D+D^2$ and $g^{(2)}(D) = 1+D^2$. Find the codeword polynomial corresponding to the information sequence, $u(D) = 1+ D^3 + D^4$. Also draw the state diagram for the given convolutional encoder.

b) Draw syndrome circuit for a (7,4) cyclic code generated by $g(x) = 1 + x + x^3$. If the received vector r is [0010110], what is the syndrome of r? Explain the circuit with a table showing the contents of the syndrome register. (10)

9 a) Explain the Viterbi algorithm for decoding of convolutional codes. (10)

b) Generate the codewords corresponding to message vector (1010) and (1100) in systematic and non-systematic form, for a (7, 4) cyclic code with $g(x) = 1 + x + x^3$. (10)

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