LNMIIT
The LNM Institute of Information Technology

Subject: Digital Communications [ECE325]

B. Tech., 3rd Year, ODD Semester, End-Term Examination

Date: 06.12.2018 **Time: 180 Minutes** **Max Marks: 50**

Instructions: 1) Please check there must be 4 questions in the paper, printed on both sides.
2) All questions are compulsory. Answer to a question should be at one place.

---

1. (a) Two 4-ary signal constellations are shown below in Fig.1. It is given that φ_1 and φ_2 constitute an orthonormal basis for the two constellations. Assume that the four symbols in both the constellations are equiprobable. Let $N_0/2$ denote the power spectral density of white Gaussian noise.

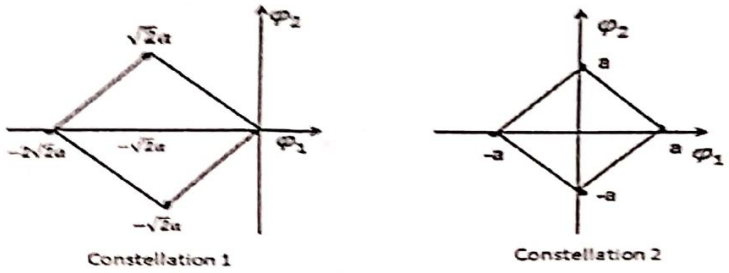

Fig. 1

What is the ratio of the average energy of constellation 1 to the average energy of constellation 2? Also, if these constellations are used for digital communications over AWGN channel then comment which is the more efficient constellation in terms of symbol error probability.

(b) In a PCM system, the signal $m(t) = \sin[100\pi t + \cos(100\pi t)]$ is sampled at the Nyquist rate. The samples are processed by a uniform quantizer with step size 0.75V. Determine the minimum data rate of the PCM system in bits per second.

(c) Bit 1 and 0 are transmitted with equal probability. At the receiver, the pdf of the respective received signals for both bits are shown below in Fig.2.

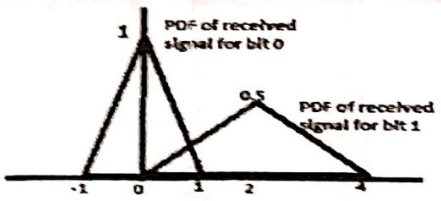

Fig. 2

Determine the BER, if the detection threshold is 1. Also find out the optimum threshold to achieve minimum BER.

(d) For a QPSK signal configuration, assuming all the symbols are equiprobable, derive the symbol error probability of the optimum receiver for an AWGN channel.

(e) The received signal in a binary communication system that employs antipodal signals is $r(t) = s(t) + n(t)$, where $s(t)$ is shown in the Fig.3 below and $n(t)$ is AWGN with power spectral density $N_0/2$ W/Hz.

(i) Sketch carefully the impulse response of the filter matched to $s(t)$.

(ii) Sketch carefully the output of the matched filter when the input is $s(t)$.

(iii) Determine the variance of the noise at the output of the matched filter at $t = 3$.

(iv) Determine the probability of error as a function of A and N_0.

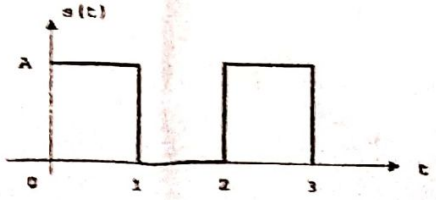

Fig. 3

[2+2+2+4+5 = 15]

2. (a) Draw the block diagram of a PLL and explain its operation by drawing the equivalent circuit of the same. How the choice of loop filter and loop gain controls the operation of a PLL? Indicate the condition to lock - i) incoming signal frequency and ii) incoming signal frequency and phase both, by showing detailed small-signal error analysis.
(b) Suppose the loop filter of a PLL has the transfer function $H(s) = 1/(s+\sqrt{2})$. Determine the closed-loop transfer function and comment on the capability of this PLL to lock incoming signal frequency/ phase/ both frequency and phase.

[6+4 = 10]

3. (a) Explain the operation of "Squaring Loop" for carrier recovery by drawing suitable block diagram. Indicate the disadvantages of this method.
(b) Why clock synchronizer is important to have in the digital communication system? Draw the block diagram and explain the operation of a bit synchronizer technique known to you.

[5+5 = 10]

4. (a) The parity check matrix of a linear block code is given below:

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

(i) Determine the Generator matrix for this code in systematic form.
(ii) How many code words are there in the code?
(iii) What is the minimum distance (d_{min}) for this code?
(iv) How many random errors per codeword can be detected and corrected?
(b) Show how the code polynomial $c(x)$ in a systematic form can be obtained given the message $d = 1011$, where the generator polynomial is $g(x) = x^3+x+1$ of a (7,4) Hamming Code.
(c) Get the condition and define Hamming bound. If you are supposed to detect and correct up to three errors, what should be the value of k and n to construct a Perfect code? What will be the Code efficiency of such a code?
(d) For the convolution encoder shown below, in Fig.4, construct the code tree and find out the codeword for the incoming data pattern 110101. What is the constraint length and code rate of such a code?

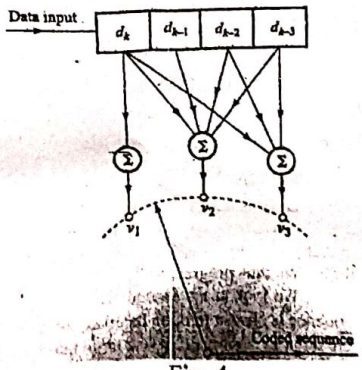

Fig. 4

[4+3+4+4 = 15]