[Total No. of Questions - 8] [Total No. of Printed Pages - 4]
(2123)

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M. Tech 1st Semester Examination

Design of Advance Digital Communication Systems

EC-104

Time : 3 Hours **Max. Marks : 100**

The candidates shall limit their answers precisely within the answer-book (40 pages) issued to them and no supplementary/continuation sheet will be issued.

Note : There are total eight question. Attempt any five questions out of eight. All questions carry equal marks.

1. (A) Derive the relation between correlation and power spectra of band pass signal? **(10)**

   (B) (a) Show that for a DMC the average mutual information between a sequence $x_1, x_2...x_n$ of channel inputs and the corresponding channel outputs satisfy the condition.

   $$I(x_1\, x_2....x_n, y_1, y_2,...., y_n) \leq \sum_{i=1}^{n} 2(x_i, y_i)$$

   with equality if and only if the set of input symbols is statistically independent.

   (b) Show that the following two relations are necessary & sufficient conditions for the set of input probabilities $\{P(x_j)\}$ to maximize I(x;y) and thus, to achieve capacity for a DMC;

   $I(x_j;y) = C$ for all j with $P(x_j)>0$

   $I(x_j;y) \leq C$ for all j with $P(x_j)=0$

   where C is the capacity of the channel &

   $$I(x_j;y) = \sum_{i=o}^{\theta-1} P(y_i \mid x_j) \log \frac{P(y_i \mid x_j)}{P(y_i)}$$ **(10)**

2. (A) Derive expression for power spectral density [PSD] of CPFSK signal. **(10)**

(B) Show that 16 QAM can be represented as a superposition of two four-phase constant envelope signals where each component is amplified separately before, summing, i.e.,

$S(t) = [A_n \cos \pi f_c t + B_n \sin 2\pi f_c t] + [C_n \cos 2\pi f_c t + D_n \sin 2\pi f_c t]$

where $\{A_n\}$, $\{B_n\}$, $\{C_n\}$ & $\{D_n\}$ are statistically independent binary sequences with elements from the set $\{+1, -1\}$. Thus, show that the resulting signal is equivalent to.

$S(t) = I_n \cos 2\pi f_c t + Q_n \sin 2\pi f_c t$

and determine I_n & Q_n in terms of A_n, B_n, C_n & D_n. **(10)**

3. (A) The two equivalent lowpass signals shown in Fig. 1 are used to transmit a binary information sequence. The transmitted signals, which are equally probable, are corrupted by additive zero mean white gaussian noise having an equivalent low pass representation z(t) with an auto-correlation function.

$\phi_{zz}(J) = \frac{1}{2} E[z^*(t) z(t+J)] = N_{o\delta}(J)$

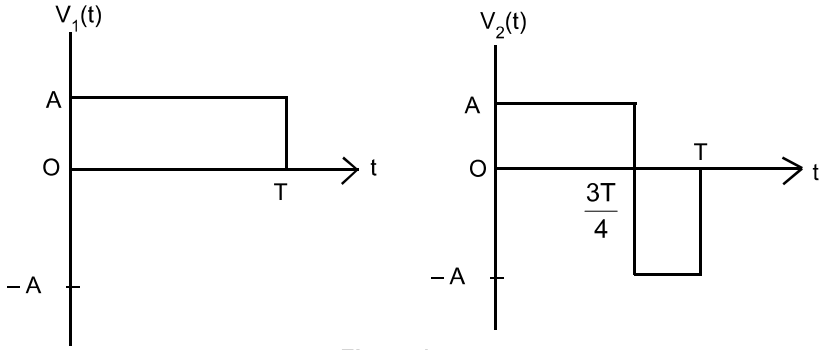

Figure 1

(a) What is the transmitted signal energy?

(b) What is the probability of a binary digit error if coherent detection is employed at the receiver?

(c) What is the probability of a binary digit error if non coherent detection is employed at the receiver? **(10)**

(B) Describe the optimum modulation for completely known signals in add time white Gaussian Noise & also find prob. of error for binary signalling. **(10)**

4. (A) (i) Derive the effect of noise on estimate of carrier phase in PLL technique.

(ii) Explain carrier tracking for multiple phase signals. **(10)**

(B) (i) Derive expression for joint ML estimation of carrier phase & symbol timing.

(ii) Evaluate performance characteristic of ML estimators. **(10)**

5. (A) (a) Explain correlator structure for acquisition in synchronization for spread spectrum systems.

(b) Explain following terms.

(i) J/S Ratio (ii) Auto-Jam Margin. **(10)**

(B) (a) Show that in a maximal-length n-stage linear feedback shift register the output stage must always be an input to the feedback network.

(b) Draw block diagram for slow frequency hopping demodulation & explain how it would work? **(10)**

6. (A) (a) (i) A BPSK signal is received at the input of a coherent optimal receiver with amplitude 10mV & frequency 1MHz. The signal is corrupted with white noise of PSD 10^{-9} W/Hz. If data is 10^4 bit/sec, find error probability. (ii) Find error probability if the local oscillator has a phase shift of $\pi/6$ radian with input signal (iii) Find error probability if there is 10% mistiming in bit synchronization while sampling & (iv) find error probability when both (ii) & (iii) occur.

(b) Find error probability for coherent FSK when (i) frequency offset is small (ii) frequencies used are orthogonal (iii) Also find error probability for non-coherent detection. Use data of above question no. 6(A)(a). **(10)**

(B) Derive probability of error for BPSK & BFSK. **(10)**

[P.T.O.]

7. (A) Mathematically describe the modulation & demodulation in an OFDM system. Explain how bank of correlators & mathed filter can be replaced by IFFT & FFT respectively. **(10)**

(B) (a) Explain in detail what type of guard period is used in OFDM system & what is significant of that in system?

(b) An OFDM symbol duration is of 1280ns. If such a frame is modulated by OFDM scheme, transmitted over the channel & received after the delay of 450ns at the receiver. What should be in minimum duration of the cyclic prefix? Show that cyclic prefix does not affect the occupied spectrum much if the number of subcariers is 64 and 64 point FFT is used. Will ISI occur? **(10)**

8. (A) Consider using 4-ary FSK.

(i) Show that if the frequencies are separated by f_s, they are each orthogonal.

(ii) Calculate the bandwidth under the condition of (i) Show that the bandwidth is five-eighths of the value required by equation (1)

$B = 2 Mf_s$ (1)

since $f_s = f_b/N$ & $M = 2^N$

Explain the difference.

(iii) Determine the ratio of bandwidths of 2-ary FSK & 4-ary FSK when the frequencies are separated by f_s Repeat for $2f_s$. **(10)**

(B) (a) Derive the expression for optimal filter transfer function.

(b) (i) For an equiprobable binary baseband data the optimal receiver receives - 5 mV for 0 & +5 mV for 1, corrupted with white noise of PSD 10^{-9} W/Hz. With optimum decision threshold what is the probability of error in reception if data rate is 9600 bit/sec? (ii) Find the % increase in error rate if data rate is doubled. (iii) If we want probability of error of increased data rate same as (i) what should be input voltage levels? **(10)**