Code: A-21 Subject: DIGITAL COMMUNICATIONS
Time: 3 Hours Max. Marks: 100

NOTE: There are 11 Questions in all.

Question 1 is compulsory and carries 16 marks. Answer to Q. 1. must be written in the space provided for it in the answer book supplied and nowhere else.
Answer any THREE Questions each from Part I and Part II. Each of these questions carries 14 marks.
Any required data not explicitly given, may be suitably assumed and stated.

Q.1 Choose the correct or best alternative in the following: (2x8)

a. In QAM scheme _____ of the carrier signal is / are varied.
(A) both frequency and amplitude. **(B)** both amplitude and phase.
(C) both phase and frequency. **(D)** only phase.

b. In an FH/MFSK system, the PN sequence makes the carrier hop over a number of frequencies in a pseudo-random manner, with the result the spectrum of the transmitted signal is spread in a

(A) random manner.
(B) sequential manner.
(C) non sequential manner.
(D) in synchronization with PN-sequence.

c. When the performance of a digital transmission system is tested with an eye-diagram, excessive deformation of pulses is indicated by a/an
(A) increased opening of the eye. **(B)** wide open eye.
(C) closing down of the eye. **(D)** blinking of the eye.

d. A concatenated code uses two levels of coding, an inner code and an outer code to achieve the desired error performance. The outer code is used for
(A) reducing channel error.
(B) reducing noise generated in modulator and demodulator.
(C) reducing probability of error to a specified level.
(D) controlling the error burst.

e. For M-ary PSK signals if the number of levels M increases, the bandwidth efficiency

(A) decreases.
(B) remains constant.
(C) reaches an optimum value and then decreases.
(D) increases.

f. The Viterbi decoding algorithm performs

(A) sequential decoding. **(B)** maximum likelihood decoding.
(C) feedback decoding. **(D)** threshold decoding.

g. Companding is a special technique used to achieve
(A) low signal to noise ratio. **(B)** non uniform sampling.
(C) differential encoding. **(D)** uniform sampling.

h. Block codes in which the message bits are transmitted in unaltered form are called
(A) structured codes. **(B)** syndromes.
(C) systematic codes. **(D)** error controlled codes.

PART I
Answer any THREE Questions. Each question carries 14 marks.

Q.2 a. Explain μ-law and A-law of compression Show that for uniform quantization process, quantization error is proportional to the square of the quantization step size. **(8)**

b. The information in an analog waveform whose maximum frequency $f_m = 3KHz$ is to be transmitted using 16 level PAM system. The quantization distortion must not exceed $\pm 1\%$ of the peak to peak analog signal.
(i) What is the minimum number of bits/sample or bits/PCM word that should be used in this PAM transmission system?
(ii) What is the minimum required sampling rate and what is the resulting bit rate?
(iii) What is the 16-ary PAM symbol transmission rate? **(6)**

Q.3 a. The term matched filter is often used synonymously with Correlator. How is that possible in spite of their mathematical operations being different? **(6)**

b. Show that the impulse response of a matched filter h(t) matched to a signal s(t) is $h(t) = K\, s(T - t)$ where T is the duration of the signal and K is the constant of proportionality. **(8)**

Q.4 a. Explain how Inter Symbol Interference (ISI) can be reduced by pulse shaping. Compare the performance degradation of communication system due to noise interference and ISI. **(8)**

b. An analog signal is PCM formatted and transmitted using binary waveforms over a channel that is bandlimited to 100 KHz. Assume that 32 quantization levels are used and that overall equivalent transfer function is of the raised cosine type with roll off factor, r = 0.6.

(i) Find the maximum bit rate that can be used by this system without introducing ISI.
(ii) Find the maximum bandwidth of the original analog signal that can be accommodated with these parameters. **(6)**

Q.5 a. Derive an expression for the probability of bit error for coherently detected BPSK signal in AWGN channel with noise power spectral density $\frac{N_o}{2}$ watts/Hz. **(8)**

b. Find the bit error for a BPSK system with a bit rate of 1 Mbps. The received waveform

$s_1(t) = A\cos\omega_o t$ and $s_2(t) = -A\cos\omega_o t$ are coherently detected with a matched filter. The value of A is 10 mv. Assume that the single sided noise power spectral density is $N_o = 10^{-11}$ W/Hz and that signal power and energy per bit are normalized relative to 1Ω load. **(6)**

Q.6 a. Explain DPSK modulation and demodulation. **(8)**

b. Calculate the minimum required bandwidth for a non-coherently detected orthogonal binary FSK system. The higher frequency signalling tone is 1 MHz and the symbol duration is 1 ms. What is the minimum required bandwidth for a non coherent MFSK system having the same symbol duration? **(6)**

PART II

Answer any THREE Questions. Each question carries 14 marks.

Q.7 Consider a (7, 4) code whose generator matrix is

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

(i) Find all the code words of the code and the parity check matrix (H) of the code.

(ii) Compute the syndrome for the received vector 1101101. Is this a valid vector? What is the error correcting capability of the code? What is the error detecting capability of the code? **(14)**

Q.8 A (15, 5) cyclic code has generator polynomial as follows :

$g(X) = 1 + X + X^2 + X^5 + X^8 + X^{10}$

(i) Draw a diagram of an encoder for this code.

(ii) Find the code polynomial (in systematic form) for the message $m(X) = 1 + X^2 + X^4$. Is $v(X) = 1 + X^4 + X^6 + X^8 + X^{14}$ a code polynomial in this system? Justify your answer. **(14)**

Q.9 a. Explain why a syndrome can be calculated by evaluating the received polynomial at each of the roots of the codes generator polynomial. **(8)**

b. Explain in brief Turbo codes. **(6)**

Q.10 a. What are the advantages of correlative coding? Explain duobinary coding and decoding. Explain precoded duobinary signalling. **(9)**

b. Consider a binary sequence $\{x_n\} = 0010110$ where the first digit of the sequence is the start up digit and not a part of data. Illustrate duobinary coding and decoding rules when differential precoding is used. **(5)**

Q.11 a. How does processing gain parameter differ for direct sequence systems as compared to frequency-hopping systems? **(6)**

b. A CDMA system uses direct sequence modulation with a data bandwidth of 10 KHz and a spread

bandwidth of 10 MHz. With only one signal being transmitted, the receive E_b/N_o is 16 dB. If the required $E_b/N_o + I_o$ is 10 dB, how many equal power users can share the band? Do not neglect receiver noise. If each user power is reduced by 3 dB, how many equal power users can share the band? Also find out the number of users that can share the band if $E_b/N_o \to \infty$. **(8)**

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