DECEMBER 2006

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

NOTE: There are 9 Questions in all.

- **Question 1 is compulsory and carries 20 marks. Answer to Q. 1. A must be written in the space provided for it in the answer book supplied and nowhere else.**
- **Out of the remaining EIGHT Questions answer any FIVE Questions. Each question carries 16 marks.**
- **Any required data not explicitly given, may be suitably assumed and stated.**

Q.1 Choose the correct or the best alternative in the following: (2x10)

a. The simplest and the most popular sampling method is

(A) Impulse sampling. **(B)** Natural sampling.
(C) Sample and hold. **(D)** None of the above.

b. In a three-bit PCM sequence, each sample is assigned to one of

(A) Four levels **(B)** Seven levels
(C) Eight levels **(D)** Sixteen levels.

c. In a frequency hopping SS system, a frequency synthesizer circuit, generates

(A) the transmitting frequency. **(B)** modulated signal frequency.
(C) maximal length sequence. **(D)** full-length sequence.

d. The general analytic expression for PSK is

(A) $s_i(t)=\sqrt{\frac{2E_i(t)}{T}}\cos(\omega_0 t+\phi)$ **(B)** $s_i(t)=\sqrt{\frac{2E}{T}}\cos[\omega_0 t+\phi_i(t)]$
(C) $s_i(t)=\sqrt{\frac{2E}{T}}\cos(\omega_i t+\phi)$ **(D)** $s_i(t)=\sqrt{\frac{2E}{T}}\cos[\omega_i t+\phi_i(t)]$
with usual notations.

e. The code rate of an (n-k) code is defined as

(A) $\left(\frac{n-k}{n}\right)$ **(B)** $\left(\frac{n-k}{k}\right)$

(C) (k/n) **(D)** $\left(\frac{n}{k}\right)$

f. In the standard array method of error correction for an (n, k) code, the number of cosets in the array are

(A) 2^{k} **(B)** 2^{n+k}
(C) 2^{n} **(D)** 2^{n-k}

g. Turbo codes were first introduced in the year

(A) 1980 **(B)** 1985
(C) 1989 **(D)** 1993

h. The maximum theoretical spectral efficiency for BPSK is

(A) 2 bps/Hz **(B)** 1 bps/Hz
(C) 3 bps/Hz **(D)** 4 bps/Hz

i. Probably the most commonly used PCM waveform is the

(A) RZ group **(B)** PN sequence
(C) NRZ group **(D)** none of the above

j. If the generator polynomial of a (7,4) cyclic code is $1+x+x^3$, then the cyclic code for the message vector 1110 in systematic form is

(A) 0101110 **(B)** 1101110
(C) 0011010 **(D)** 1011110

Answer any FIVE Questions out of EIGHT Questions.
Each question carries 16 marks.

Q.2 a. What is the first process that transforms an analog waveform that is compatible with a digital communication system? What is the type of waveform produced by this process? State Nyquist criterion. **(6)**

b. What do you mean by natural sampling? What is the significance of the word 'natural' in the above process of sampling? Describe quantitatively the flatftop sampling method. Also explain aperture effect. **(10)**

Q.3 a. What is non-uniform quantisation? Give one technique of achieving non-uniform quantisation? With neat illustrations, describe briefly the following:

(i) Non-uniform quantiser characterstic.
(ii) Compression characteristic.
(iii) Uniform quantiser characteristic. **(12)**

b. Illustrate duo binary coding and decoding for the following sequence:

{x (k)} = 0010110
Consider the first bit of the sequence to be a startup digit and not part of the data. **(4)**

Q.4 a. Define 'equivalence theorem' as used in base band detection. Why only the thermal noise characteristics are most often used to model the noise in the detection process and in the design of receivers? Give the representation of the transmitted signals over a symbol interval (0,T) for any binary channel. Distinguish between the terms 'demodulation' and 'detection' as used in digital communication. **(7)**

b. Briefly describe the concept of 'maximum likelihood detector'. **(6)**

c. A bipolar binary signal s_i (t), is a +1 or –1 V pulse during the interval (0,T). Additive white Gaussian noise having two-sided power spectral density of 10^{-3} W / Hz is added to the signal. If the received signal is detected with a matched filter, determine the maximum bit rate that can be sent with a bit error probability of $P_B \leq 10^{-3}$. **(3)**

Q.5 a. Define 'band pass modulation'. List the basic non-coherent band-pass signalling schemes used in practice. What is the advantage of noncoherent over coherent systems and what is the price paid? **(8)**

b. Illustrate by a neat sketch the signal space and decision regions for a QPSK system. Comment on the decision rate for the detector. **(5)**

c. Estimate the theoretical maximum spectral efficiency for the QPSK scheme. **(3)**

Q.6 a. Deduce the equation for the probability of bit error for non-coherently detected binary orthogonal FSK. **(12)**

b. Binary data is transmitted over a channel with usable bandwidth of 2400 Hz using the FSK signalling scheme. The transmit frequencies are 1025 and 1225 Hz, and the data rate is 300 bits/sec. The average signal to noise power ratio at the output of the channel is 5.99 dB.

Calculate the probability of error if the demodulation scheme is non-coherent. **(4)**

Q.7 a. Name two commonly used types of error control. How do they work? What do you mean by a 'systematic linear block code and what is the generator matrix for such a code? **(8)**

b. A (7, 4) block code is generated by the matrix

$$\begin{bmatrix} 1000 & 111 \\ 0100 & 110 \\ 0010 & 101 \\ 0001 & 011 \end{bmatrix}$$

Compute: (i) the code vector for a message block (1011).

(ii) the syndrome for the code vector obtained above.

(iii) if the third bit of the code vector obtained above, suffered an error in the transmission, then what is the syndrome of the received vector R? **(8)**

Q.8 a. What is the complete significance of the minimum distance of a linear code; why not the maximum distance? What are the advantages of binary cyclic codes? **(6)**

b. How is a convolutional code described? Briefly highlight the important characteristic of convolutional codes. **(5)**

c. Illustrate a (2,1) convolutional encoder with constraint length of three by using the connection pictorial representation. What do you mean by ' the impulse response' of the encoder? Obtain the output of the encoder by superposition of the time-shifted input impulses, for an input sequence of 101 to the encoder. **(5)**

Q.9 a. How do the LPI communication systems operate? What is the goal of such a system? How is the resulting power in spread spectrum system, on an average spread and what is the idea behind the above choice? **(7)**

b. Briefly describe the following properties that can be applied to any periodic sequence as a test for the appearance of randomness: (i) balance property (ii) Run property. **(5)**

c. A base-band correlator for despreading CDMA signals is shown in the figure **(4)**

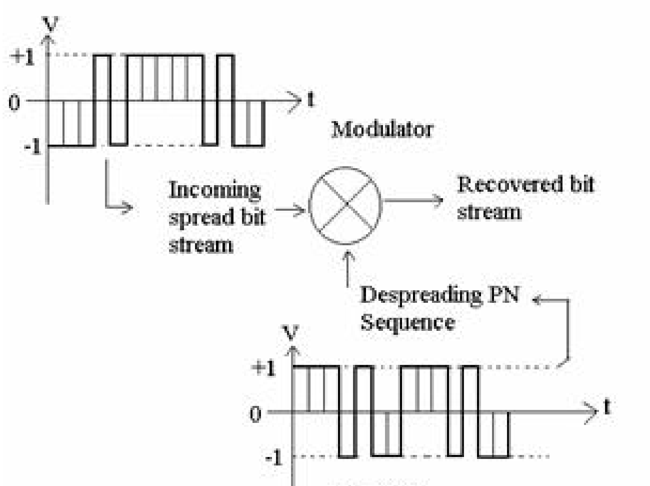

Fig. 9 (c)

ream recovery from the above configuration with relevant

e transmitter?

oming spread bit stream and the recovered bit stream rate.