JUNE 2008

Code: AE21 **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. 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 one or mark, is represented by a change in level, and the zero or space is represented by no change in level with the

(A) NRZ-L PCM waveforms
(B) Multilevel binary PCM waveforms
(C) NRZ-M PCM waveforms
(D) RZ-M PCM waveforms

b. A system using a raised cosine roll-off filter characteristic is transmitting binary data at 9600 bits per second using 8-ary PAM. If the system has a frequency response out to 2.4 KHz, then the roll-off factor of the filter characteristic is

(A) 2 **(B)** 0.79
(C) 0.21 **(D)** 0.5

c. A generator polynomial g(x) of an (n,k) cyclic code is a factor of

(A) X^{n+1} **(B)** X^{n-k-1}
(C) $X^{n}+1$ **(D)** $X^{n}-1$

d. If the input to a receiver consists of the QPSK signal plus white Gaussian noise and the bit rate is 2400 bits per second, then the minimum transmission bandwidth required for the communication system is

(A) 2400 Hz **(B)** 1200 Hz
(C) 4800 Hz **(D)** None of the above

e. In a standard array used for the error correction with a (n,k) block code, each COSET consists of

(A) 2^{n} K-tuples

(B) 2^n n-tuples

(C) 2^K n-tuples

(D) 2^k K-tuples

f. For large energy-to-noise ratios the symbol error performance $P_E(M)$ for equally likely coherently detected M-ary PSK signalling can be expressed as

(A) $Q\left(\sqrt{\frac{2E_S}{N_o}}\sin\frac{\pi}{M}\right)$ **(B)** $2Q\left(\sqrt{\frac{2E_S}{N_o}}\sin\frac{M}{\pi}\right)$

(C) $\frac{1}{2}Q\left(\sqrt{\frac{2E_S}{N_o}}\sin\frac{\pi}{M}\right)$ **(D)** $2Q\left(\sqrt{\frac{2E_S}{N_o}}\sin\frac{\pi}{M}\right)$

with usual notations.

g. The minimum number of PN chips that are required for each frequency word for a hopping bandwidth of 400 MHz and a frequency step size of 100 Hz is

(A) 12 **(B)** 30
(C) 42 **(D)** 22

h. The processing gain for frequency hopping spread spectrum system is written as G_p equals

(A) W_{ss}/R **(B)** $\frac{R_{ch}}{R}$

(C) $\frac{W_{hopping}}{R}$ **(D)** $\frac{E_s}{N}$

i. The minimum $\frac{E_b}{N_o}$ decibels required to achieve an error rate of 10^{-5} for the noncoherent DPSK signalling scheme is

(A) > 9.6 dB **(B)** < 9.6dB
(C) > 12.5 dB **(D)** > 10.4 dB

j. The extended Golay code is formed by

(A) adding an overall Parity bit to the Perfect (24,12) code
(B) adding an overall Parity bit to the Perfect (23,12) code
(C) adding an overall Parity bit to the Perfect (12,23) code
(D) adding an overall Parity bit to the Perfect (12,24) code

Answer any FIVE Questions out of EIGHT Questions.

Each question carries 16 marks.

Q.2 a. How are bandpass digital communication signals produced? With a neat sketch, illustrate aliasing in the frequency domain. Also, illustrate how higher sampling rate eliminates aliasing. Support your answer with relevant comments. **(8)**

b. Derive an expression for maximum Signal to Noise Ratio (SNR) in PCM system that uses Linear quantization. **(8)**

Q.3 a. When do you get an M-ary Pulse modulation waveform? Name the four important groups to which the PCM waveforms fall. Which is the group that is probably the most commonly used PCM waveform? What are the parameters worth examining in choosing a PCM waveform for a particular application? **(12)**

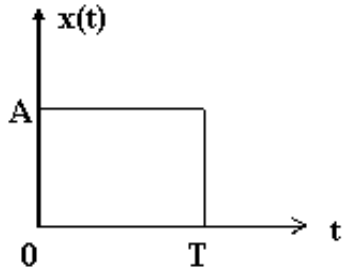
b. Explain correlative-level coding and construct duobinary coding and decoding for the following sequence:

$$\{x_k\} = 0\,0\,1\,0\,1\,1\,0$$

Assume the first bit of the sequence to be a startup digit, not part of the data. **(4)**

Q.4 a. Indicate the quantity that is considered as a standard quality measure for the performance of a digital communication system and what is the unit of the above quantity? Define a matched filter, suppose that a known signal s(t) plus AWGN n(t) is the input to the LTI receiving filter followed by a sampler, find the filter transfer function $H_o(f)$ that maximises the ratio of the instantaneous signal power to the average noise power at a time t=T Out of the sampler. **(10)**

b. Determine the impulse response and output of Matched filter, if input x(t) is



(6)

Q.5 a. What is bandpass modulation? List the basic noncoherent bandpass signalling schemes used in digital communication system. **(6)**

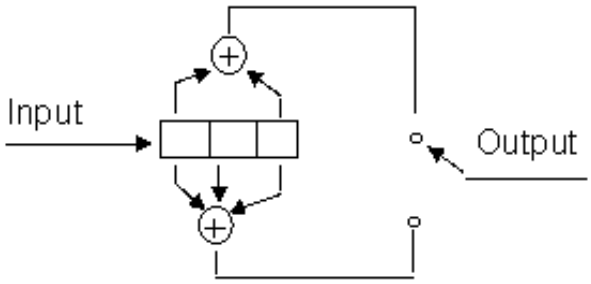
b. What is ASK modulation? Write the general analytic expression for ASK and indicate the features of BASK signalling. **(6)**

c. A continuously operating coherent BPSK system has a data rate of 1000 bits/sec. The single-sided noise power spectral density is $N_o = 10^{-10}$ W/Hz. If the value of the received average signal power is adjusted to be 10^{-6} W, What is the average bit error probability? **(4)**

Q.6 a. Make a comparison of bit error performance for various modulation types. **(10)**

b. A system using matched filter detection of equally likely BPSK signals, $s_1(t) = \sqrt{\frac{2E}{T}} \cos \omega_o t$ and $s_2(t) = \sqrt{\frac{2E}{T}} \cos(\omega_o t + \pi)$, operates in AWGN with a recieved (E_b/N_o) of 6.8 dB. Assume that $E[Z(t)] = \pm\sqrt{E}$. If the decision threshold is $\gamma = 0.1\sqrt{E}$, find the minimum probability of bit error P_B. **(6)**

Q.7 a. Draw the state diagram, tree diagram and trellis diagram for the convolutional encoder characterized by block diagrams. **(6)**



b. Name the matrix which enables the communication engineer to decode the received vectors when working with linear (n,k) systematic block codes. How are the components of the above matrix written and what are the two properties required of the same? **(4)**

c. For a message vector 1011, find the cyclic code in systematic form generated using the generator polynomial $g(X) = 1 + X + X^3$. **(6)**

Q.8 a. Write the error detection scheme with an (n–k) stage shift register for a (7, 4) cyclic code, if the input to the scheme in polynomial form is $(1 + X^3 + X^5 + X^6)$. Assume the generator polynomial as $(1 + X + X^3)$. Explain the operation of the scheme you would use. **(9)**

b. Explain 'TURBO CODES' and compare its performance with convolutional codes. **(7)**

Q.9 a. Consider an FH/MFSK system. Let the PN generator be defined by a 20-stage linear feedback shift register with a maximal length sequence. The minimum step size between center frequencies (hop to hop) is 200 Hz. The register clock rate is 2 KHz. Assume that 8-ary FSK modulation is used and that the data rate is 1.2 kbits/s.

(i) What is the hopping bandwidth?

(ii) What is the processing gain? **(4)**

b. What is the usual design goal of an anti-jam communication system? Which is the ratio that is considered as a figure of merit and which provides a measure of how in-vulnerable a system is to interference? Derive the analytical expression for the above quantity. **(9)**

c Which system has better Jammer-rejection capability? Justify your answer. **(3)**