Code: AE-21 **Subject: DIGITAL COMMUNICATIONS**

JUNE 2007

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

a. To minimise the slope overload noise while holding the granular noise at a reasonable value

(A) PCM is used. **(B)** DPCM is used.
(C) ADM is used. **(D)** PAM is used..

b. A one is represented by a half-bit wide pulse and a zero is represented by the absence of a pulse with

(A) Bipolar-RZ PCM waveform **(B)** Unipolar-RZ PCM waveform
(C) RZ-AMI PCM waveform **(D)** QPSK waveform

c. The co-error function is defined as

(A) $Q(x) = \frac{1}{\sqrt{\pi}} \int_{-\infty}^{x} e^{-u^2/2}\, du$. **(B)** $Q(x) = \frac{1}{\sqrt{2\pi}} \int_{x}^{\infty} e^{+u^2/2}\, du$.

(C) $Q(x) = \frac{1}{2\sqrt{\pi}} \int_{x}^{\infty} e^{-u^2/2}\, du$. **(D)** $Q(x) = \frac{1}{\sqrt{2\pi}} \int_{x}^{\infty} e^{-u^2/2}\, du$.

d. The modulation scheme that requires a system bandwidth much larger than the minimum bandwidth that would be required by the message is

(A) MSK modulation **(B)** Continuous phase modulation
(C) Spread spectrum modulation **(D)** Quadrature amplitude modulation.

e. The input to a receiver consists of the OOK signal plus white Gaussian noise and the bit rate is 2400 bits / sec. For the communication system, then the minimum bandwidth required is

(A) 1200 Hz **(B)** 4800 Hz
(C) 2400 Hz **(D)** 2000 Hz

f. If the amplitude of the received waveform for a BPSK system is 10 mV and bit rate is 1Mbps, then the bit energy in Joules is

(A) 3×10^{-1}J **(B)** 5×10^{-11}J
(C) 2×10^{-1}J **(D)** 4×10^{-10}J

g. In a linear block code, for each $(k\times n)$ generator matrix 'G', there exists a parity check matrix 'H' of size

(A) $(k-n)\times k$ **(B)** $k\times(n-k)$
(C) $(n-k)\times n$ **(D)** $k\times n$

h. The processing gain in a DSSS-CDMA system which employs BPSK, with an information bit rate of 64 k bits/sec and a chip rate of 25.7 mega chips per second is

(A) 20 dB **(B)** 18 dB
(C) 26 dB **(D)** 22 dB

i. For an (n,k) linear systematic code, the components of the parity check matrix are written as

(A) $H=\left[\frac{I_{n-k}}{P}\right]$ (B) $H=\left[P^T : I_K\right]$
(C) $H=\left[P : I_k\right]$ (D) $H=\left[I_{n-k} : P^T\right]$

j. If m(t) is the polar baseband data signal then the signal $s(t)=A_c\cos[\omega_c t+D_p m(t)$ represents the

(A) CPFSK signal (B) DPSK signal
(C) BPSK signal (D) ASK signal

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

Q.2 a. State uniform sampling theorem for lowpass signal. Discuss the most economic solution for the task of transforming an analog signal to a digital signal or the reverse, for proving the above theorem. **(13)**

b. Sketch the naturally sampled PAM waveform that results from sampling a 1-KHz sine wave at a 4-KHz rate. Repeat the above for the case of a flat-topped PAM waveform. **(3)**

Q.3 a. When do you get a pulse-code modulation waveform? With an example, describe the wave form representation of binary digits. Support the description with necessary illustrations. **(11)**

b. Find the step size delta (δ) required to prevent slope overload noise for the case when the input

signal is a sine wave, in the design of a DM system. Comment on the value of 'δ' to be used to take care of granular noise. **(5)**

Q.4 a. Name the quantity that is used as a figure of merit in digital communications. How do you compare the above with the figure of merit of the analog communication system? Why can't we use the same quantity used for analog communication systems for digital communications also? **(9)**

b. An analog signal is PCM formatted and transmitted using binary waveforms over a channel that is band limited to 100 KHz. Assume that 32 quantisation levels are used and that the overall equivalent transfer function is of the raised cosine type with roll off of 0.6. Find

(i) the maximum bit rate that can be used by this system without introducing ISI.

(ii) the maximum bandwidth of the original analog signal that can be accommodated with these parameters. **(7)**

Q.5 a. What is digital modulation? Write four points what you know of non coherent demodulation. **(6)**

b. What is phase shift keying? Write its general analytic expression. Briefly explain BPSK modulation. **(6)**

c. If a system's main performance criterion is bit error probability, which of the following two modulation schemes would be selected for an AWGN channel? Show computations,

Binary non coherent orthogonal FSK with $\frac{E_b}{N_o} = 13\text{dB}$

Binary coherent PSK with $E_b/N_o = 8\text{dB}$. **(4)**

Q.6 a. Derive the equation of bit error probability for non coherently detected binary orthogonal FSK. **(10)**

b. Find the probability of bit error for the coherent matched filter detection of equally likely binary FSK signals.

$s_1(t) = 0.5\cos 2000\pi t$ and $s_2(t) = 0.5\cos 2020\pi t$

where the two-sided AWGN power spectral density is $\frac{N_o}{2} = 0.0001$. Take the symbol duration as 0.01s. **(6)**

Q.7 a. Distinguish between Forward Error Correction (FEC) and Automatic Repeat Request (ARQ) used for error control. What are the advantages of ARQ over FEC? **(6)**

b. What do you mean by a systematic (n, k) linear block code? To fulfil the orthogonality requirements for a systematic code, how are the components of the parity check matrix written? What is the use of the parity check

matrix? **(4)**

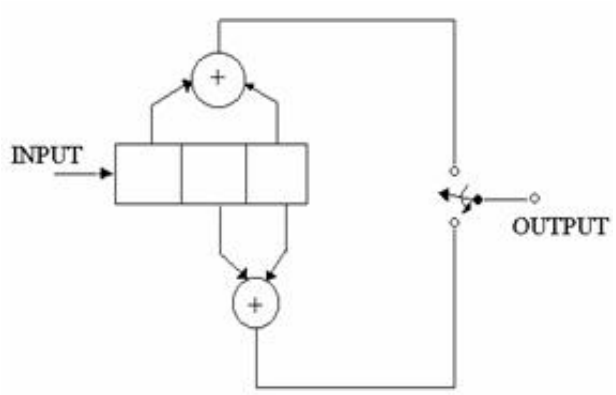
c. The generator matrix for a (6, 3) block code is

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

What is the code word for the message $\{1 \quad 1 \quad 0\}$? Suppose that the above codeword is transmitted and the vector r = 001110 is received. Which of the received bits is in error? Find the syndrome vector value S and verify that it is equal to eH^T . **(6)**

Q.8 a. Write the scheme of a (7, 4) cyclic encoder for a message block 1011. Explain its operation and compute the output of the encoder. Take the generator matrix as $\{1+X+X^3\}$ and use an (n-k) stage shift register for the encoder. **(8)**

b. A convolutional encoder is shown in the figure below. Draw the state diagram and tree diagram.



Q.9 a. Consider a DS/BPSK spread-spectrum transmitter. Let x(t) be the sequence 100110001 arriving at a rate of 75 bits/sec and let g(t) be equal to 111100010011010

(i) Sketch the final transmitted sequence x(t).g(t).

(ii) What is the bandwidth of the transmitted (spread) signal? **(5)**

b. Name the parameter used to measure the communication links error performance as a function of interference and deduce an expression for the same in terms of the processing gain G_p. **(6)**

c. Write a brief note on anti-jamming margin. **(5)**