Indian Statistical Institute

Mid Semestral Examination: 2025

Course: M. Tech. in Computer Science

Subject: Computer Networks

Date: 24-02-2025 Total Marks: 60 Duration: 2 hours 30 minutes

Instructions: You **may** attempt **all** questions which cary a total of **65** marks. However, the maximum marks you can score is only **60**.

1 (a) The attenuation of a signal is 0 dB. What is the final signal power if the initial signal power was P Watt? [2]

(b) For the signal modeled by the sine wave $sin(100\pi t)$, is it appropriate to perform samples at the rate of 50 samples/second for accurate collection of data? Justify your answer. [3]

(c) Suppose that the spectrum of a noisy channel is between 5 MHz and 10 MHz, and $SNR_{dB} = 10\log_{10}(63)$ dB. What is the maximum bit rate on this channel? How many signal levels are needed to achieve such bit rate? [3+2=5]

(d) Derive the expression for $\frac{E_b}{N_o}$ in terms of spectral efficiency when data rate equals channel capacity. [5]

2 (a) For the bit stream 1 0 0 0 1 1 0 0 1, for each of the following encoding schemes, sketch the waveforms and mention whether it produces any DC component:

i. NRZ-L.

ii. Bipolar AMI.

iii. Differential Manchester. [(2+1)+(2+1)+(2+1)=9]

Assume that the signal level for the most recent preceding 1 bit for Bipolar AMI was a positive voltage.

(b) Consider an MFSK scheme with carrier frequency f_c equals to 100 kHz, difference frequency f_d equals to 10 kHz, and number of different signal elements M equals to 4. Make a frequency assignment for each of the 4 possible 2-bit data combinations. Determine the transmission bandwidth. Assume that the value of modulation and filtering parameter r is 0. [4+2=6]

(c) What is the maximum data rate that can be transmitted using a QPSK modulation with a transmission bandwidth of 36 MHz. Assume that the value of modulation and filtering parameter r is 0.2. What are the maximum phase shifts that can occur in QPSK and OQPSK (offset/orthogonal QPSK)? [2+2=4]

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(d) The number of quantization levels is increased from 8 to 64 keeping the same sampling rate. What is the factor that increases the bandwidth needed to transmit the PCM signal? [3]

(e) An amplitude modulation (AM) wave is represented by the expression :

$$S(t) = \frac{1}{4}[\cos(1800\pi t) + cos(2200\pi t)] + cos(2000\pi t).$$

Determine the amplitude modulation index and the frequencies of the lower and upper sideband components. [3+1+1=5]

3 (a) A direct sequence spread spectrum (DSSS) system uses a feedback shift register of length $m = 10$ for generating PN-sequence. The chip duration is $T_c = 1$ microsecond and the bit duration is $T_b = NT_c$ where N is the length of the m sequences. Determine the processing gain of the system in dB. Determine the jamming margin in dB if the required $\frac{E_b}{N_o}$ to achieve satisfactory performance is 10. Assume $10^3 \approx 1023$. [1+2=3]

(b) Out of the frequency hopping spread spectrum (FHSS) and direct sequence spread spectrum (DSSS) systems, which one allows for a greater processing gain? Which of the slow FHSS and fast FHSS systems has the most difficulty maintaining phase coherence? Justify your answer. [2+2=4]

(c) For the code $\{111, 100, 001, 010\}$, determine the number of message bits transmitted by each codeword and the minimum Hamming distance of the code. Is the code linear? Justify your answer. [1+3+1=5]

(d) Suppose a code uses n-bit codewords for $k = 5$ message bits. What's the minimum value of n that will permit the code to be used for single bit error correction? [3]

(e) Consider the use of CRC with generator polynomial $G(x) = x^3 + 1$ for error detection. Show the transmitted string for the message string 1 0 0 1 1. Construct a burst error of length 4 on the transmitted string in such a way that the error cannot be detected by the CRC with the given $G(x)$. [4+4=8]