B.E. COMPUTER SCIENCE & ENGINEERING 2nd YEAR 2nd SEMESTER EXAM- 2024
DATA COMMUNICATION

Time: 3 hours **Full Marks: 100**

Group A (Total Marks: 20) [CO1 and CO2]
Answer Question No. 1 (Compulsory) and Question No. 2 OR Question No. 3

1. (a) Explain the responsibilities of the Physical Layer and Data Link Layer in the Internet model.

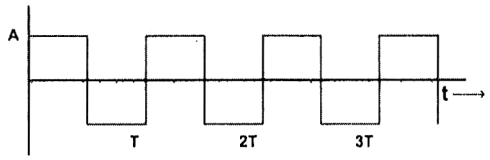
   (b) Assume that two computers C1 and C2 are communicating via the Internet. C1 is connected to LAN1 and C2 is connected to LAN3. LAN1 is connected to LAN2 via router R1 and LAN2 is connected to LAN3 via router R2. The sender computer C1 is running two processes with port addresses sp1 and sp2. The receiver computer C2 is running three processes with port addresses rp1, rp2 and rp3. Process sp1 needs to communicate with process rp2 for file transfer.

   (i) Why are the port addresses of the sender and receiver computers not the same?

   (ii) Show how the sender C1 encapsulates its data in different layers of the Internet model using a schematic diagram.

   (iii) Why do physical addresses change from hop to hop, but the logical and port addresses usually remain the same. Show the contents of the frame at the data link layer for each hop from C1 to C2 with a schematic diagram. 3+(1+2+4)

2. (a) Consider a square wave form as shown below. Decompose it into its harmonics and show the frequency domain representation.



   (b) Assume the following two cases:
   Case 1: Low pass channel with wide bandwidth
   Case 2: Low Pass channel with limited bandwidth
   Explain how the shape of the digital signal is preserved in the above two cases.

   (c) Calculate the required bandwidth of a low pass channel if we need to send 500 kbps by using baseband transmission? 3+(2+3)+2

3. (a) Describe the Nyquist bit rate formula and Shannon capacity to determine the theoretical highest data rate of a channel.

   (b) Assume a channel with 1-MHz bandwidth. The SNR for this channel is 63. Apply Nyquist bit rate formula and Shannon capacity to find the appropriate bit rate and signal level.

   (c) Calculate the propagation time and transmission time for a 5-Mbyte message (say an image) to reach your friend at 15000 km if the bandwidth of the network is 1Gbps? 4+3+3

Group B (Total Marks: 25) [CO3]
Answer Question No. 4 (Compulsory) and Question No. 5 OR Question No. 6

4. (a) Analyze the polar schemes NRZ-L, NRZ-I, RZ, Manchester and Differential Manchester in respect to (i) Baseline Wandering (ii) DC components (iii) Self-Synchronization. Illustrate with suitable diagrams and examples and discuss how these schemes are affected or overcome the problems.

   (b) Explain what price you have to pay for digitization using the above polar schemes and bipolar AMI and Pseudoternary scheme in terms of bandwidth.

   (c) "The bipolar scheme (AMI or Pseudoternary) has the same signal rate as NRZ" - Explain the benefits of bipolar scheme over NRZ.

   (5X2)+3+2

5. Illustrate the main steps of Pulse Code Modulation technique to change an analog signal to digital data. What are the restrictions on sampling rate?

   (i) A complex low-pass signal has a bandwidth of 200 KHz. What is the minimum sampling rate for this signal?

   (ii) A complex band-pass signal has a bandwidth of 200 KHz. What is the minimum sampling rate for this signal? 4+2+2+2

6. (a) How 8B/10B prevent a long run of 0s and 1s? Let us consider a system that needs to send data at Q Mbps. Find the minimum bandwidth requirement of the following combination of coding schemes: 4B/5B and NRZ-I.

   (b) Explain a technique for digital to digital conversion that does not increase the number of bits and does provide synchronization. What issue does the sequence 110000100000000 face? Apply that technique for the sequence 110000100000000 and illustrate with a schematic diagram. (2+3)+(2+3)

Group C (Total Marks: 25) [CO4]
Answer Question No. 7 (Compulsory) and Question No. 8 OR Question No. 9

7. (a) Analyze and illustrate the constellation diagrams for ASK (with peak amplitude values of 2 and 4), BPSK (with a peak amplitude value of 3) and QPSK (with a peak amplitude value of 4) signals in respect to in-phase (I) and quadrature carriers (Q).

   (b) Compare the bandwidth requirement of Amplitude Modulation, Frequency Modulation and Phase Modulation techniques. Apply that to find the bandwidth for the following situations if you need to modulate a 8-kHz voice. (i) AM (ii) FM ($\beta = 5$) (iii) PM ($\beta = 1$). (3X3)+(3+3)

8. (a) Assume that a voice channel occupies a bandwidth of 4 kHz. You need to combine three voice channels into a link with a bandwidth of 15 kHz, from 20 to 35 kHz. Show the configuration using the frequency domain and explain with a schematic diagram. What will be the size of the guard band between the channels to prevent interference?

(b) Define FHSS and explain how it achieves bandwidth spreading. (4+2)+4

9. (a) Analyze how the duration of an output time slot is n times shorter than the duration of an input time slot in synchronous TDM. Explain the concept of interleaving in TDM.
Assume 4 channels are multiplexed using TDM. If each channel sends 100 bytes/s. If 1 byte per channel at a time is multiplexed, find the duration of (i) each input slot (ii) each output slot (iii) each frame.

(b) Assume you have a spreading code of n chips. If the original signal rate is N, find the rate of the spread signal. Can the bandwidth sharing of DSSS be the same as FHSS? -Justify your answer. (2+2+3)+(1+2)

Group D (Total Marks: 15) [CO5]
Answer any one i.e., Question No. 10 OR Question No. 11

10. (a) Illustrate the geometric concept for finding d_{min} in error detection and correction.

(b) Describe the relationship between n and k in a Hamming code. Assume you need a dataword of at least 16 bits. Apply the relationship of n and k to calculate their values in the C(n,k) with d_{min}=3.

(c) What are the main characteristics of a good polynomial generator? Analyze the suitability of the following generators in relation to burst errors of different lengths L <= r, L = r+1 and L > r+1, where r is the degree of the polynomial.
(i) $x^{18} + x^7 + x + 1$
(ii) $x^{32} + x^{23} + x^7 + 1$ 4+(2+3)+(2+2+2)

11. (a) A sender needs to send the four data items 0x3456, 0xABCC, 0x02BC, and 0xEEEE. Answer the following:

(i) Calculate the checksum at the sender site.

(ii) Calculate the checksum at the receiver site if there is no error.

(iii) Calculate the checksum at the receiver site if the second data item is changed to 0xABCE. Can checksum detect this error? Explain your answer.

(iv) Calculate the checksum at the receiver site if the second data item is changed to 0xABCE and the third data item is changed to 0x02BB. Can checksum detect this error? Explain your answer.

(b) What is the condition for a Hamming code to correct a single error or detect a double error? Can you make it detect a burst error of size 4 bits ? Illustrate your answer with a suitable example and schematic diagram. (2+2+3+3)+(2+3)

Group E (Total Marks: 15) [CO6]
Answer any one i.e., Question No. 12 OR Question No. 13

12. (a) Assume that, in a Stop-and-Wait ARQ system, the bandwidth of the line is 1 Mbps, and 1 bit takes K ms (last 2 digits of your exam roll number) to make a round trip.

(i) Calculate the bandwidth-delay product.

(ii) If the system data frames are 1000 bits in length, calculate the utilization percentage of the link?=.

(iii) What do you think about utilization of the link in case of high bandwidth or long delay?

(iv) Assume you have a protocol that can send up to 15 frames before stopping and worrying about the acknowledgement. What is the utilization percentage of the link in that case?

(v) What do you think about the efficiency of Stop-and-Wait ARQ? How that efficiency can be improved in Go-Back-N ARQ

(b) Why is the size of the send window less than 2^m in Go-Back-N ARQ? Illustrate your answer with a suitable flow diagram. (5X2)+5

13. (a) Assume that the forward channel is reliable but the reverse is not. No data frames are lost, but some ACK are delayed and one is lost. Illustrate with flow diagram how cumulative acknowledgements are effective in Go-Back-N ARQ to address delayed or lost acknowledgements.

(b) Why is the size of the sender and receiver windows at most one half of 2^m? Illustrate your answer with a suitable flow diagram.

(c) Assume m=3 and frame 1 is lost. Show how Selective Repeat ARQ protocol behaves in this case. Illustrate your answer with a suitable flow diagram. 5+5+5