B.E. COMPUTER SCIENCE & ENGINEERING 2nd YEAR 2nd SEMESTER EXAM- 2025
DATA COMMUNICATION

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

Group A (Total Marks: 20) [CO1 and CO2]

1. **Answer any two**

(a) Explain the functionalities of each layer of TCP/IP protocol suite with suitable diagrams. What is the relation between Nyquist bit rate formula and Shannon capacity to determine the theoretical highest data rate of a channel? 6+4

(b) Assume that we have a digital signal of bit rate N. Discuss the approximation (rough and better) of this digital signal with an analog signal in a low-pass channel with limited bandwidth. Assume hypothetically that we have two links of the same delay, say 5 sec. The bandwidth of these links are 1 bps and 5 bps respectively. Discuss the performance of these two links. 3+4+4

(c) Why two separate frequencies are used for uplink and downlink transmission in case of satellite communication? Assume that we have a digital signal of bit rate N. Discuss the approximation (rough and better) of this digital signal with an analog signal in a low-pass channel with limited bandwidth. The digital signal is to be designed to permit 160 kbps for a bandwidth of 20 KHz. Determine (a) number of levels and (b) SNR. 2+6+2

Group B (Total Marks: 25) [CO3]
Answer Question No. 2 (Compulsory) and Question No. 3 OR Question No. 4

2. (a) Describe (i) Baseline Wandering (ii) DC components (iii) Self-Synchronization. Explain the Manchester and Differential Manchester schemes (with suitable diagram and example) and discuss how they overcome the problems associated with other polar schemes? What is the main drawback of Manchester and Differential Manchester schemes?

(b) Describe the pulse code modulation technique for digitization (with suitable diagram). Explain what price you have to pay for digitization in terms of bandwidth. Derive the minimum bandwidth if the data rate and number of signal levels are fixed. (3X2+2)+(3+2+2)

3. Why do we need encoding of data before sending over a medium? What is quantization error? How can it be reduced? What is the result of scrambling the sequence 11100000000000 using a) B8ZS b) HDB3 scrambling techniques? Assume that the last non-zero signal level has been positive. Explain in accordance with the rules of each scheme. 2+2+(3+3)

4. "The bipolar scheme (AMI or Pseudoternary) has the same signal rate as NRZ" - Explain the benefits of bipolar scheme over NRZ. 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. 3+4+3

Group C (Total Marks: 25) [CO4]
Answer Question No. 5 (Compulsory) and Question No. 6 OR Question No. 7

5. (a) Show that the bandwidth with d=0 in multilevel FSK is B=L X S. Assume that the available bandwidth is 100 kHz, which spans from 200 to 300 kHz. What should be the carrier frequency and the bit rate if data is modulated using FSK with d = 1?.

   (b) What are the two components of a signal when the signal is represented on a constellation diagram? Explain with a diagram. Show the constellation diagrams for ASK, BPSK and QPSK. Apply (i) AM (ii) FM ($\beta = 5$) (iii) PM ($\beta = 1$) to find the bandwidth to modulate a 48-kHz audio. 5+(4+6)

6. "In synchronous TDM, the data rate of the link is *n* times faster, and the unit duration is *n* times shorter."- Explain it. Assume that there are four sources, each creating 250 characters per second. If the interleaved unit is a character and 1 synchronizing bit is added to each frame, find (i) the data rate of each source, (ii) the duration of each character in each source, (iii) the frame rate, (iv) the duration of each frame, (v) the number of bits in each frame, and (vi) the data rate of the link. 4+6

7. Explain how FHSS and DSSS can achieve bandwidth sharing. Four 1-kbps connections are multiplexed together. A unit is 1 bit. Find (i) the duration of 1 bit before multiplexing, (ii) the transmission rate of the link, (iii) the duration of a time slot and (iv) the duration of a frame. (3+3)+4

Group D (Total Marks: 15) [CO5]
Answer any one i.e., Question No. 8 OR Question No. 9

8. (a) Describe the relationship between n and k in a Hamming code. A Hamming code can only correct a single error or detect a double error - Explain a procedure to make it detect a burst error. Illustrate the geometric concept for finding d_{min} in error detection and correction.

   (b) Let us consider a sender has some data in hexadecimal as follows: 6AB2 C37D 6FEA C4DE. If it is required to calculate the checksum, then show the checksum calculation in the sender site (assume that a 16-bit checksum is used).
   Now, suppose an error has occurred during transmission, and consequently the 8th and 12th hexadecimal digits from the left are changed to 'F' and 'C' respectively. In this scenario, show the checksum at the receiver site. (3+3+3)+6

9. (a) Let G(x) be the generator polynomial used for CRC checking. What is the condition that should be satisfied to detect (i) single bit errors, (ii) two isolated single bit errors and (iii) odd number of errors.

(b) Let us consider a CRC generator polynomial is given below:

$$x^{32} + x^{26} + x^{23} + x^{22} + x^{16} + x^{12} + x^{11} + x^{10} + x^8 + x^7 + x^5 + x^4 + x^2 + x + 1$$

Answer the following questions.

(i) How many single-bit errors can be detected by this generator polynomial? Please justify your answer.

(ii) How many out of 10^{12} burst errors of size 33 are left undetected. Provide the calculation.

(iii) How many out of 10^{12} burst errors of size 56 are left undetected. Provide the calculation.

(iv) Is it capable of detecting a burst error of size 17? Justify your response.

7+8

Group E (Total Marks: 15) [CO6]
Answer any one i.e., Question No. 10 OR Question No. 11

10. (a) To improve the efficiency of transmission, multiple frames must be in transition while waiting for acknowledgement. Discuss the design (with suitable diagram, flowchart/algorithm) of a protocol to achieve this goal in noisy channels.

(b) Let us consider a Go-back-N ARQ system, where the sequence number field is 4 bits long. Also consider the system can send 7.8 Megabytes per minutes through the link and 20000 μs is required for a bit to make a round trip. What will be the improvement in the maximum link utilization percentage in this scheme compared to the Stop-and-Wait ARQ scheme (assume that each frame is of 1000 bits in length). If the maximum link utilization of the Go-back-N ARQ system improves to 86%, what will be the length of the sequence number field?

(c) 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.

5+5+5

11. (a) Assume 6 bits are used to represent the sequence number. W_s and W_r denote send and receive window size respectively. Find the values of W_s and W_r for (i) Stop-and-Wait ARQ (ii) Go-Back-N ARQ (iii) Selective Repeat ARQ.

(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) A node is using the following sequence numbers
0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,0,1,2,3,.... 5+5+5
Assume frame 1 is lost. Show how Selective Repeat ARQ protocol behaves in this case with a suitable flow diagram.