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Unit I

1 Data Communication and Network Models

1.1 : Introduction to Communication Theory

Q.1 Explain data communication and its components.

Ans. : Basics of data communication

- **Data communications** is the exchange of data between two devices by means of any transmission medium. The effectiveness of data communication system depends on three **fundamental characteristics** delivery, accuracy and timeliness.
  1. **Delivery :** The data must be delivered to the intended device or user.
  2. **Accuracy :** The data must be delivered accurately i.e. without alteration.
  3. **Timeliness :** The system must deliver data in a timely manner.
  4. **Jitter :** It refers to the variation in packet arrival time.

Data communication system

- A data communication system consists of five components.

  1) Message 2) Sender 3) Receiver 4) Medium 5) Protocol

Fig. Q.1.1 shows components of data communication system.

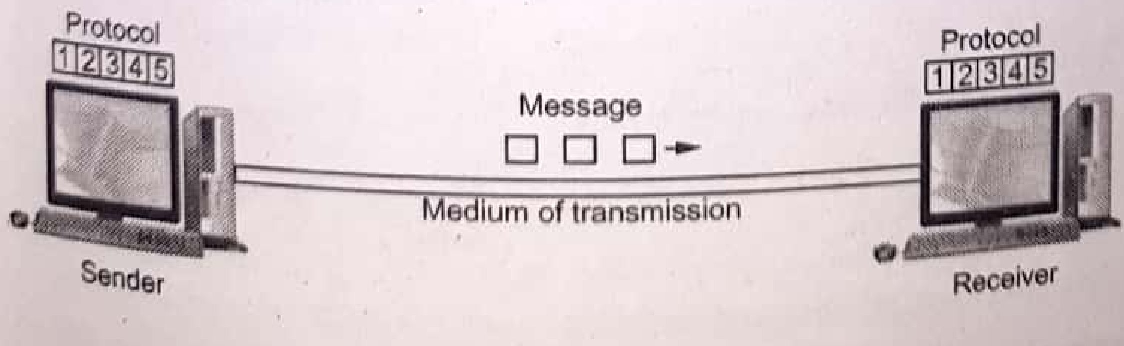


Fig. Q.1.1 Data communication components

1. **Message :** The message is data or information to be communicated. It can be text, numbers, pictures or sound.
2. **Sender :** The sender is device that sends data. Various devices can be used to send the data.
3. **Receiver :** The receiver receives the information/message transmitted by sender.
4. **Medium :** It is a physical path through which message passes from sender to receiver. The transmission medium can be twisted-pair cable, co-axial cable, fiber-optic cable or radiowaves.
5. **Protocol :** Protocol is a set of rules that governs data communications. Protocol is a predecided terms for communication.

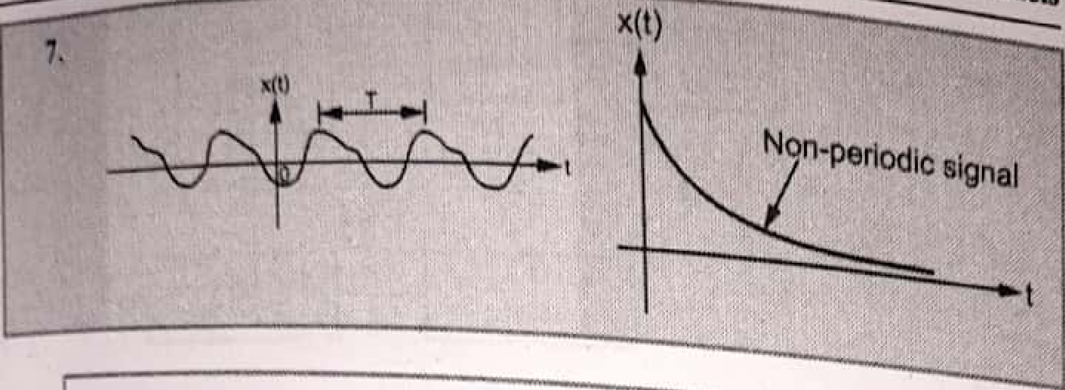
1.2 : Types of Signals

Q.2 Give comparison of periodic and aperiodic signals.

Ans. : Comparison of Periodic and Aperiodic Signals

Sr. No.	Periodic signal	Aperiodic signal
1.	A signal which repeats itself after a specific interval of time is called periodic signal.	A signal which does not repeat itself after a specific interval of time is called aperiodic signal.
2.	A signal that repeats its pattern over a period is called periodic signal.	A signal that does not repeats its pattern over a period is called aperiodic signal or non periodic..
3.	They can be represented by a mathematical equation.	They cannot be represented by any mathematical equation.
4.	Their value can be determined at any point of time.	Their value cannot be determined with certainty at any given point of time.
5.	They are deterministic signals	They are random signals
6.	Example : Since, cosine,square, sawtooth etc.	Example : Sound signals from radio, all types of noise signals.

7.



1.3 : Signal Conversion Methods : A/D Conversion

Q.3 Draw and explain PCM and DM.

☞ [SPPU : May-17,18, Dec.-17, Marks 7]

Or Explain pulse code modulation and delta modulation with suitable diagram.

☞ [SPPU : Dec.-19, Marks 6]

Ans. : PCM :

- The most common technique to change an analog signal to digital data is called pulse code modulation (PCM). With PCM, the pulses are of fixed length and fixed amplitude. PCM is a binary system where a pulse or lack of a pulse within a prescribed time slot represents either a logic 1 or a logic 0 condition.
- Fig. Q.3.1 shows a simplified block diagram of a single channel, simplex PCM system. The bandpass filter limits the frequency of the analog input signal to the standard voice band frequency range of 300 Hz to 3000 Hz.
- The analog signal is sampled every T_s where T_s is the sample interval or period. The inverse of the sampling interval is called the sampling rate or sampling frequency. The sample and hold circuit periodically samples the analog input signal and converts those samples to a multilevel PAM signal.
- The analog to digital converter converts the PAM samples to parallel PCM codes, which are converted to serial binary data in the parallel to serial converter and then outputted onto the transmission line as serial digital pulses.

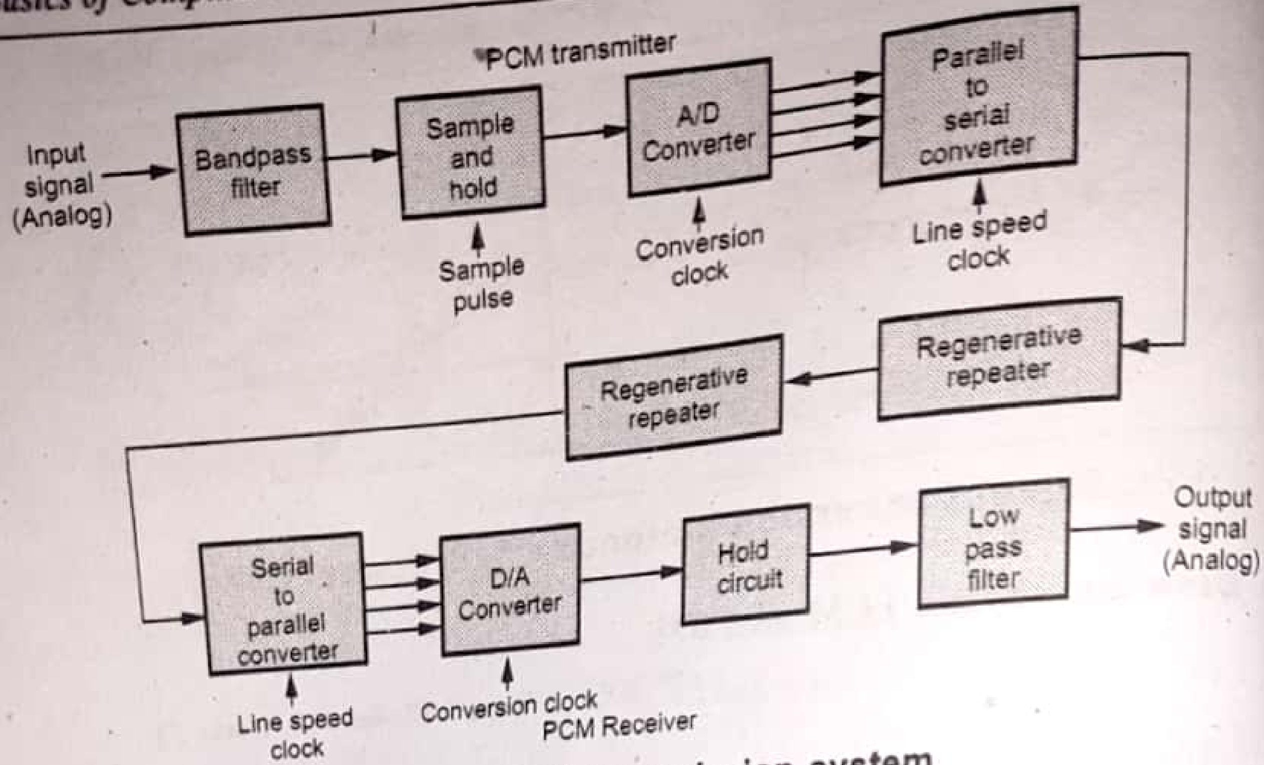


Fig. Q.3.1 PCM transmission system

- Sampling methods are ideal, flat and natural.
- In ideal sampling, pulses from the analog signal are sampled. In natural sampling, a high speed switch is turned on for only the small period of time when the sampling occurs.

DM :

- Delta modulation minimize the effects of noise without increasing the number of bits being sent. This increases signal to noise ratio, improving system performance. Delta modulation take samples close enough to each other so that each samples amplitude does not vary by more than a single step size. Then instead of sending a binary code representing the step size, a single bit is sent signifying whether the sample size has increased or decreased by a single step.
- Fig. Q.3.2 shows the delta modulator and demodulator.
- Fig. Q.3.2 shows the functional block diagram. Samples from the original signal are compared to the output of a staircase generator. If the results of that comparison show the original signal to be larger than the staircase voltage, the comparator is set high. This is sent out as a logic 1 and causes the staircase generator to increase by a step. If the comparator indicates that the staircase voltage is greater than the

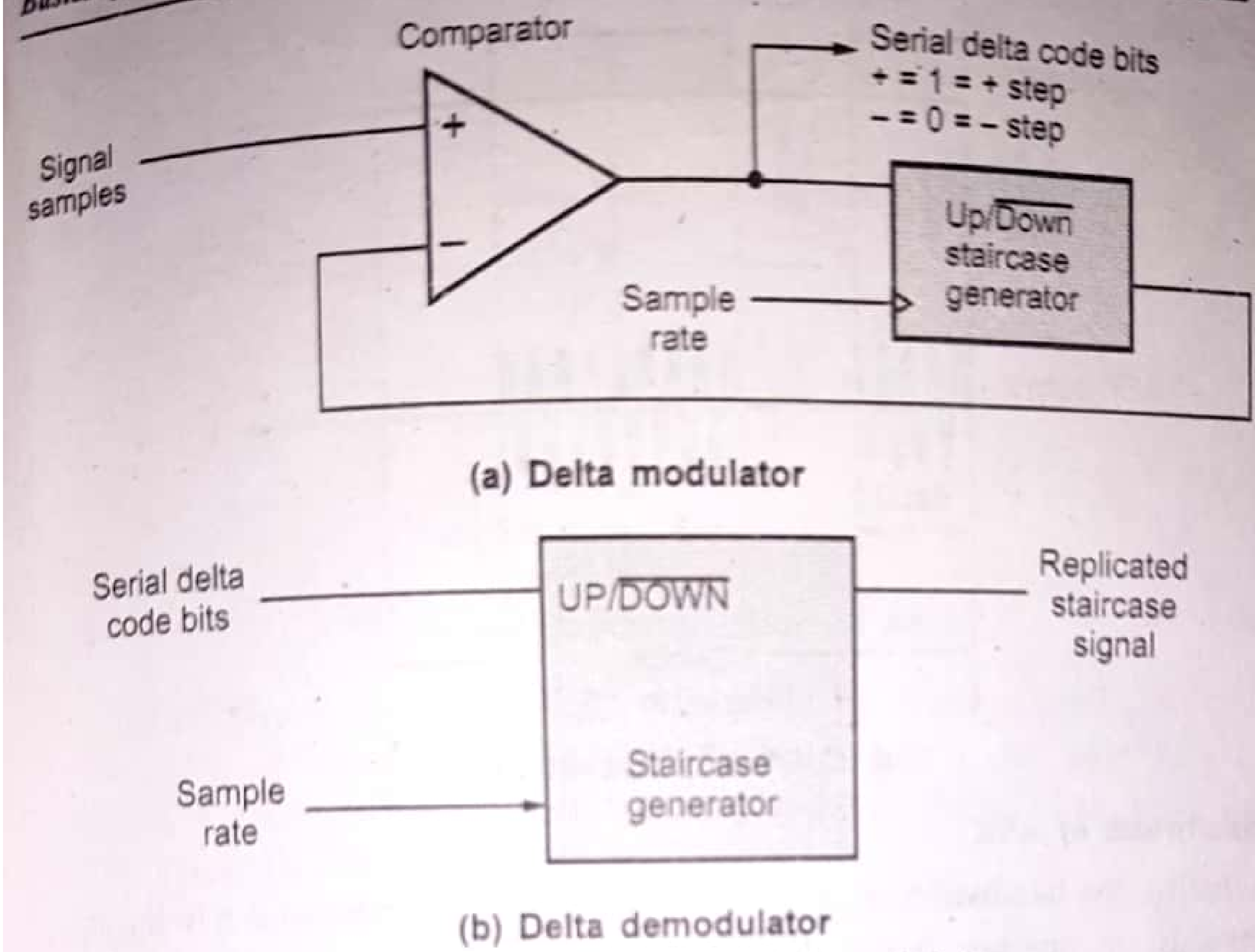


Fig. Q.3.2 Delta modulator / demodulator

original signal, then the comparator goes low and causes the staircase generator to decrease by one step.

1.4 : D/A Conversion

Q.4 Explain the following shift keying techniques with suitable examples :
i) ASK ii) FSK iii) PSK ☞ [SPPU : May-17, 18, Dec.-17, 19, Marks 7]

Ans. : (i) ASK

- In ASK, the amplitude of carrier signal is varied in accordance with digital information, the frequency and phase remains constant.
- ASK is implemented using two levels only hence sometimes called as binary ASK or on-off keying. Fig. Q.4.1 shows binary ASK (BASK) waveform.

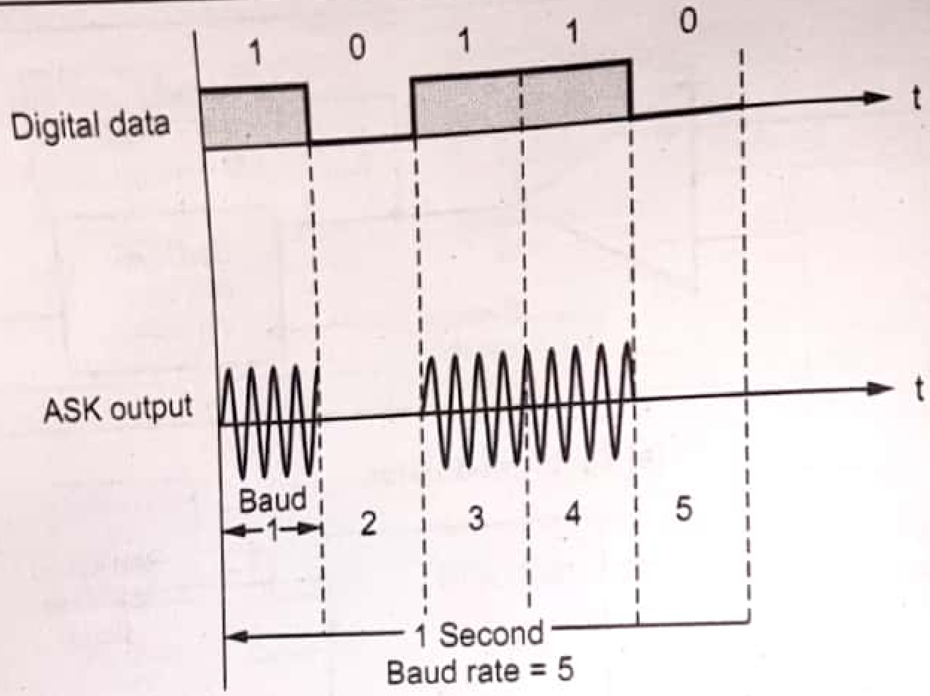


Fig. Q.4.1 ASK waveform

1. Bandwidth of ASK

- Actually, the bandwidth is proportional to the signal rate/baud rate but it depends on another factor d, that represents modulation and filtering process. The value of d is between 0 and 1.
- Bandwidth is given by :

$$B = (1+d)\ S$$

where,

S is signal rate and

B is bandwidth.

- Fig. Q.4.2 shows bandwidth of ASK.

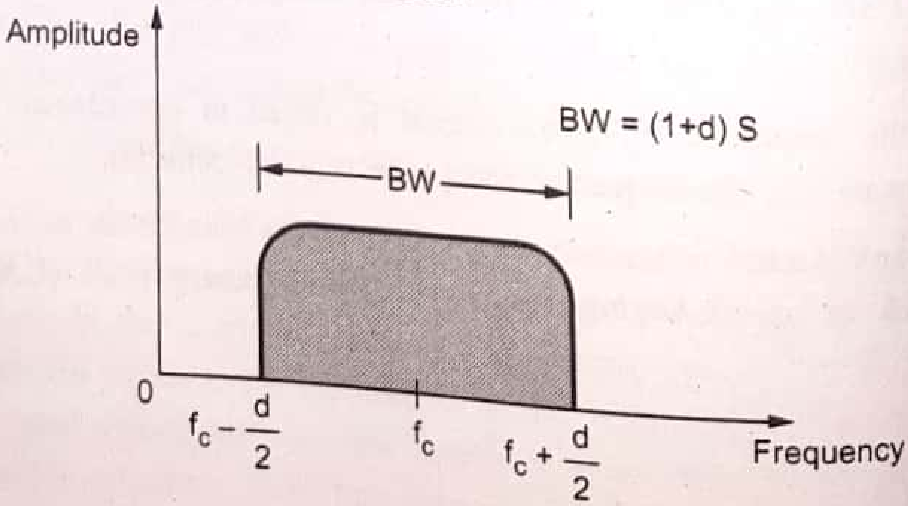


Fig. Q.4.2 BW of ASK

2. Implementation of ASK

- Fig. Q.4.3 shows simple implementation of ASK.

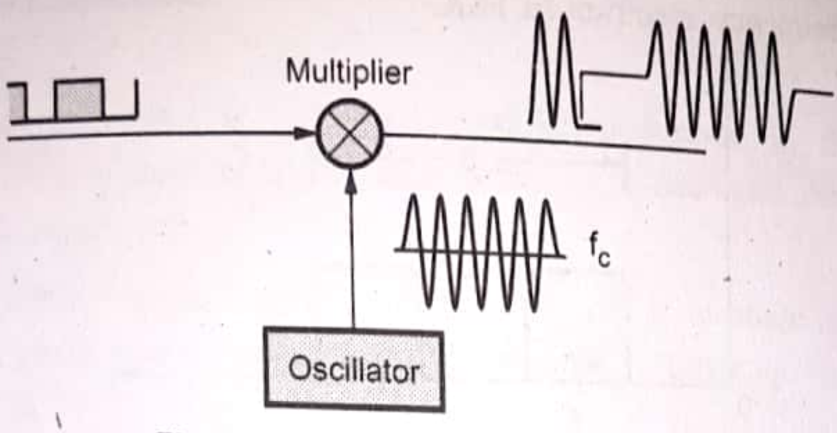


Fig. Q.4.3 Implementation of ASK

The digital data (unipolar NRZ) is multiplied by carrier signal generated by oscillator. When the amplitude of digital data is 1, the amplitude of carrier frequency is high, when the amplitude of digital data is 0, the carrier frequency amplitude becomes 0.

(ii) FSK

- In Frequency Shift Keying (FSK), the frequency of carrier signal is varied between two discrete values f_1 and f_2.
- When data element is 0, first carrier frequency f_1 is used and when data element is 1, second carrier frequency f_2 is used. Both carrier frequencies have same amplitude.
- Fig. Q.4.4 shows binary FSK waveforms.

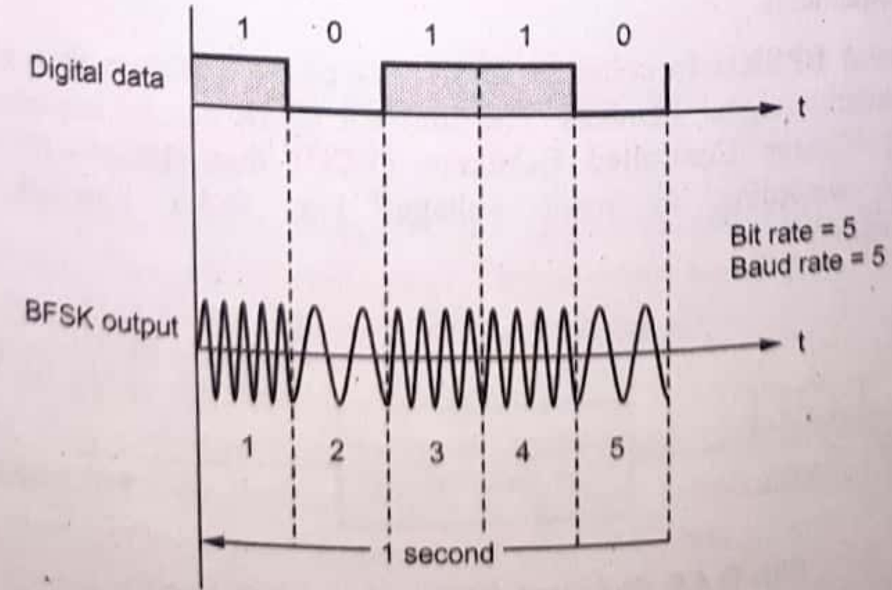


Fig. Q.4.4 FSK waveform

1. Bandwidth of BFSK

- The FSK modulation creates a nonperiodic composite signal. Fig. Q.4.5 shows frequency spectrum of FSK.

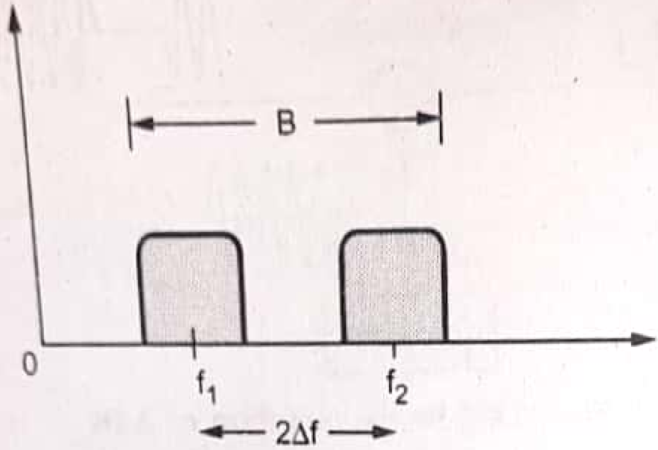


Fig. Q.4.5

- f_1 and f_2 are center frequencies of two carrier signal. If the difference between f_1 and f_2 is $2\Delta f$. The bandwidth expression can be written as -

$$B = (1+d)S + 2\Delta f$$

2. Implementation of BFSK

- There exists two variations of BFSK implementation noncoherent and coherent.

1) Noncoherent BFSK : In noncoherent BFSK, there is discontinuity in the phases of two consecutive signal element. The noncoherent BFSK is implemented by treating BFSK as two ASK modulations and using two carrier frequencies.

2) Coherent BFSK : In coherent BFSK, the phase continues through the two consecutive signal elements. The coherent BFSK can be implemented by using Voltage Controlled Oscillator (VCO) that changes its input frequency according to input voltage. Fig. Q.4.6 illustrate this implementation.

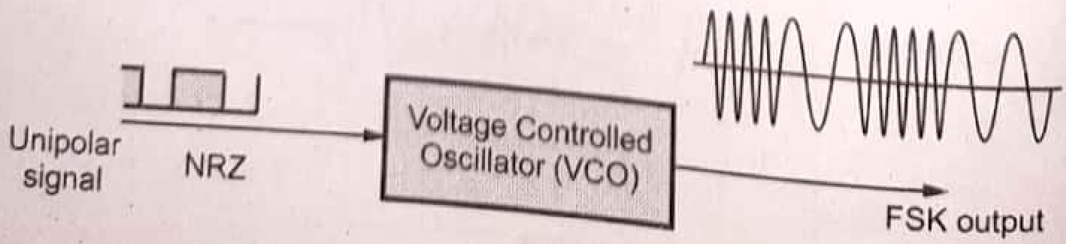


Fig. Q.4.6 Coherent BFSK implementation

The input to VCO is unipolar NRZ signal, when its amplitude is zero, the output has normal frequency and when input signal amplitude is high the frequency is increased.

(iii) PSK

- The BPSK scheme is two level modulation scheme as therefore it represents two states of digital data (0 and 1), it decreases the baud rate and bandwidth.
- When BPSK uses two separate modulations one is in phase and other is out of phase (quadrature). Hence the scheme is called quadrature PSK or QPSK.
- Fig. Q.4.7 shows the QPSK waveform.

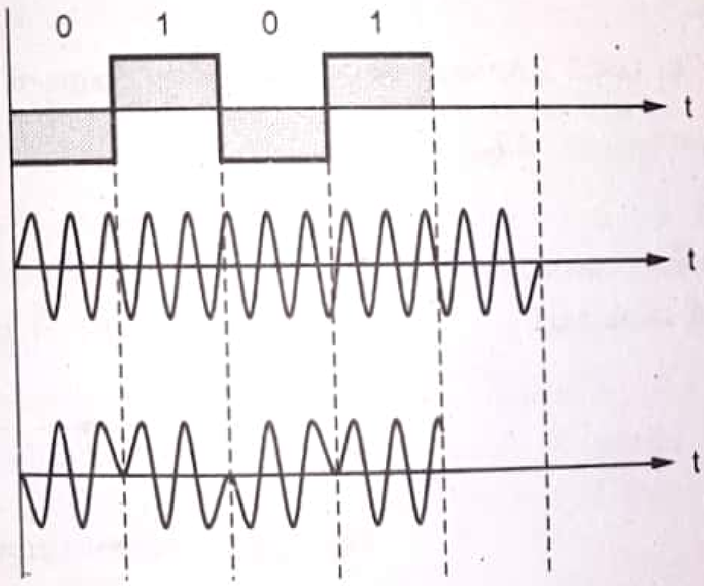


Fig. Q.4.7 QPSK waveform

Constellation diagram

- Constellation diagram specifies the amplitude and phase of a signal element. The signal element is represented as a dot. The bit or combination of bits it carry is written near the dot.
- Constellation diagram has two axes. X-axis represents carrier in-phase and Y-axis represents quadrature (out-of-phase) carrier. The projection of dot on X-axis gives amplitude of in-phase component. The projection of dot on Y-axis gives amplitude of quadrature components.

- Fig. Q.4.8 shows the concept of constellation diagram.

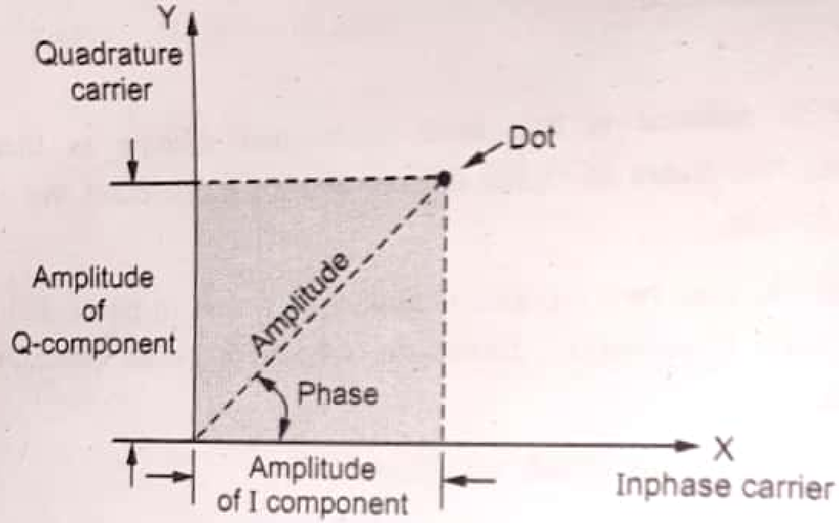


Fig. Q.4.8 Concept of constellation diagram

Constellation diagram of ASK

- Only one in-phase carrier is used. Two points on same axis.

Fig. Q.4.9 Constellation diagram of ASK

Constellation diagram of BPSK

- Only one in-phase carrier is used. A polar NRZ modulation creates two opposite signal element.

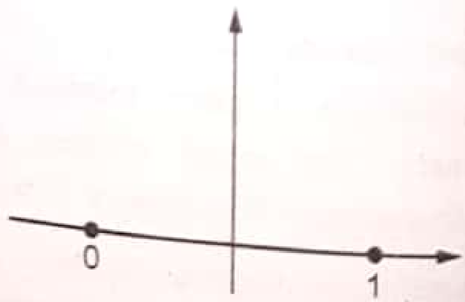


Fig. Q.4.10 Constellation diagram of BPSK

Constellation diagram of QPSK

QPSK uses two carriers in opposite phases.

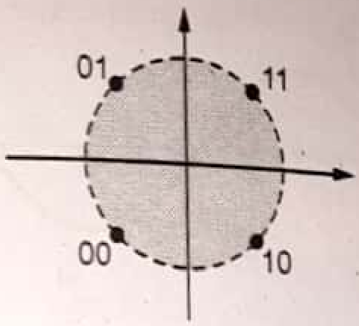


Fig. Q.4.11 Constellation diagram of QPSK

1.5 : A/A Conversion

Q.5 With the help of diagram explain AM. Write mathematical expression of AM modulated signal. ☞ **[SPPU : May-18, Dec.-19, Marks 6]**

Or What is an AM wave ? Derive a mathematical expression for AM wave. ☞ **[SPPU : Dec.-18, Marks 6]**

Ans. : • In amplitude modulation, it is the voltage level of the signal to be transmitted that changes the amplitude of the carrier in proportion.

- Fig. Q.5.1 (See Fig. Q.5.1 on next page) shows amplitude modulation.
- With no modulation, the AM carrier is transmitted by itself. When the modulating information signal (a sine wave) is applied, the carrier amplitude rises and falls in accordance. The carrier frequency remains constant during amplitude modulation.
- Amplitude modulation or AM as it is often called, is a form of modulation used for radio transmissions for broadcasting and two-way radio communication applications.
- The amplitude of a sinusoidal signal with fixed frequency and phase is varied in proportion to a given signal is called as **amplitude modulation**.
- In the modulation process, some characteristic of a high-frequency carrier signal (bandpass), is changed according to the instantaneous amplitude of the information (baseband) signal.

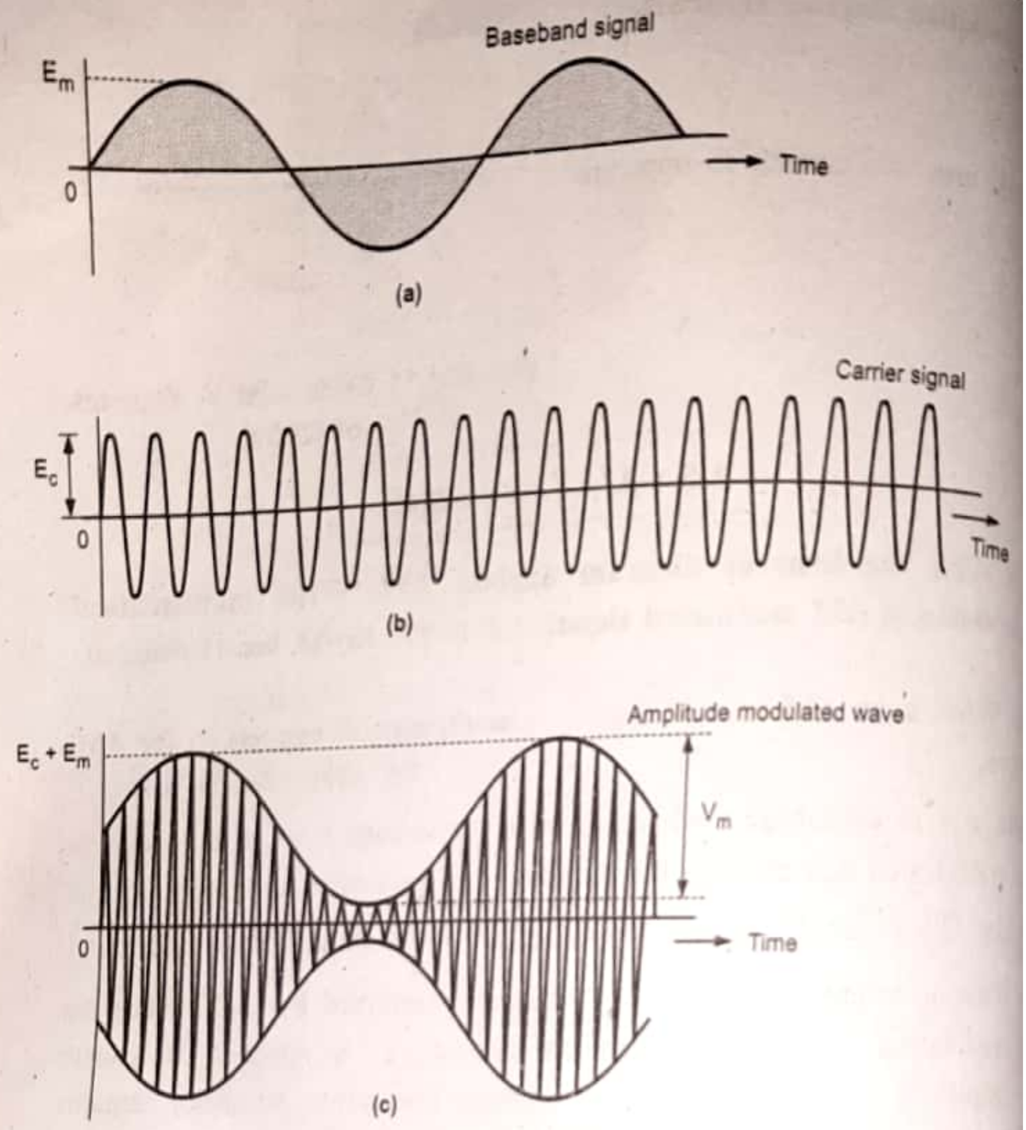


Fig. Q.5.1 (a) Sinusoidal modulating signal
(b) Sinusoidal high frequency carrier
(c) Amplitude modulated signal

- The amplitude of high-carrier signal is varied according to the instantaneous amplitude of the modulating message signal m(t). An AM signal is made up of a carrier (with constant frequency) in which its amplitude is changed (modulated) with respect to the signal (modulating signal) we wish to transmit (voice, music, data, binary).
- AM is the process of changing the amplitude of a relatively high frequency carrier signal in proportion to the instantaneous value of the modulating signal. It is relatively inexpansive, low quality form of

modulation that is used for commercial broadcasting of both audio and video signals.

- AM is also used for two way mobile radio communications, such as citizens band radio.
- AM modulators are two input devices. One input is a single, relatively high frequency carrier signal of constant amplitude, and the second input is comprised of relatively low frequency information signals that may be a single frequency or a complex waveform made up of many frequencies.
- The modulating signal modulates amplitude, frequency or phase of the carrier according to its variations in amplitude. This results in amplitude, frequency or phase modulation. The frequency and phase modulation is also called angle modulation.
- When the amplitude of the modulating signal is greater than the amplitude of the carrier, distortion will occur, causing incorrect information to be transmitted. In amplitude modulation, it is particularly important that the peak value of the modulating signal be less than the peak value of the carrier.

Demodulation of AM Signals

- Demodulation extracting the baseband message from the carrier. There are two main methods of AM demodulation :
  1. Envelope or non-coherent detection or demodulation.
  2. Synchronised or coherent demodulation.

Advantages of AM :

1. Simple implementation.
2. Less complex circuitry.
3. Cheaper components so easy to build AM transmitter and receiver.

Disadvantages of AM :

1. Power usage in modulation is not efficient.
2. Bandwidth requirement is very high.
3. Prone to noise and hence AM transmission is highly noisy.
4. Difficult to tune in absence of the carrier.

Amplitude modulation techniques :

1. Double Sideband Suppressed Carrier (DSBSC)
2. Double Sideband Full Carrier (DSFSC)
3. Single-Sideband (SSB)

Q.6 A carrier of 1000 W is modulated with a resulting modulation index of 0.8. What is the total power ? ☞ [SPPU : Dec.-17, Marks 6]

Ans. :

$$P_t = P_C\left(1+\frac{\mu^2}{2}\right)$$

$$P_t = 1000\left(1+\frac{0.8^2}{2}\right)$$

$$P_t = \mathbf{1320\ Watt}$$

Q.7 Draw frequency domain representation of AM wave. A standard AM broadcast station is allowed to transmit modulating frequencies upto 5 kHz. If the AM station is transmitting on a frequency of 980 kHz, what are sideband frequencies and total bandwidth ?

☞ [SPPU : Dec.-17, Marks 6]

Ans. : Sideband frequencies are,

$$f_{USB} = f_c + f_m = 980 + 5 = 985 \text{ kHz}$$

$$f_{LSB} = f_c - f_m = 980 - 5 = 980 \text{ kHz}$$

$$\text{Total BW} = 2f_m = 2 \times 5 \text{ kHz} = 10 \text{ kHz}$$

Q.8 What is FM ? Derive a mathematical expression for FM wave.

☞ [SPPU : May-19, Marks 6]

Ans. : • In Frequency Modulation (FM), the frequency of the carrier is varied according to amplitude variations in the modulating signal. But the amplitude of the frequency modulated signal remains constant. The frequency modulated carrier by sinusoidal modulation is shown in Fig. Q.8.1.

• When the modulating signal has zero amplitude, then the carrier has frequency of ω_c or f_c. As the amplitude of the modulating signal increases, the frequency of the carrier increases. Similarly, as the amplitude of the modulating signal is decreased, the frequency of carrier

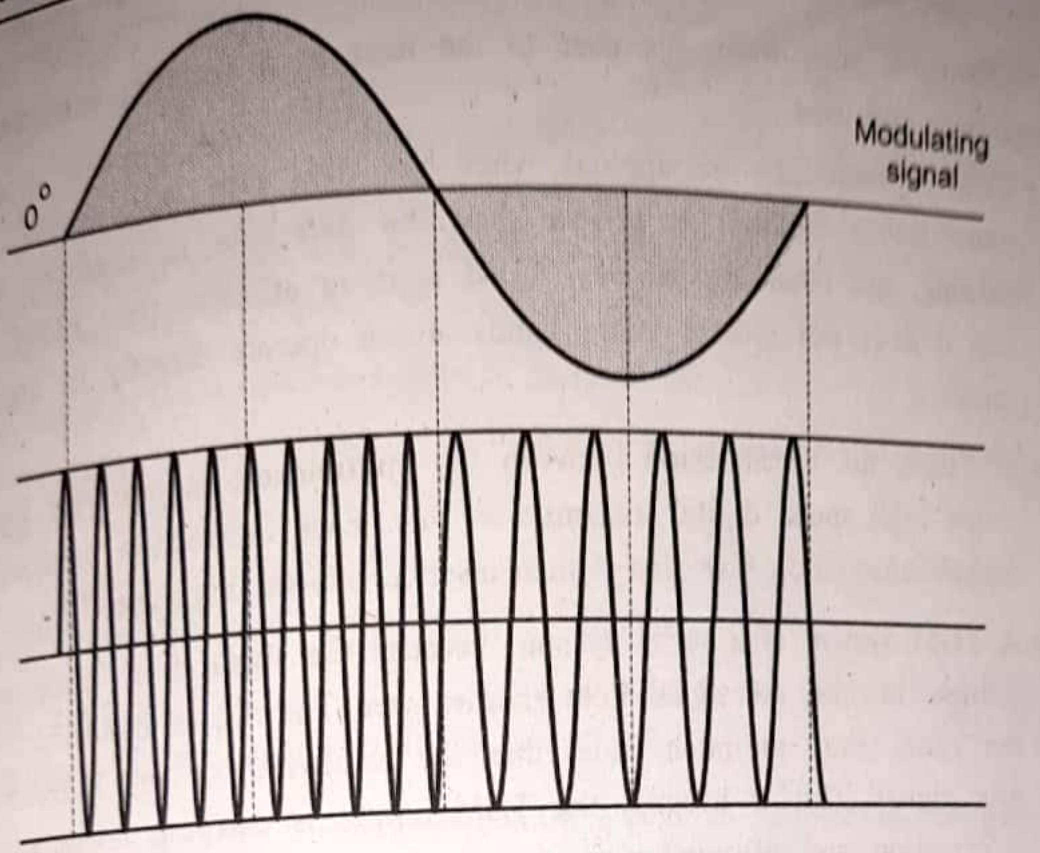


Fig. Q.8.1 Frequency modulation

is also decreased. Observe in Fig. Q.8.1 that the amplitude of frequency modulated carrier is constant.

- The mathematical equation of the FM signal is given as

$$e_{FM} = E_c \sin(\omega_c t + m_f \sin \omega_m t) \quad \dots (Q.8.1)$$

Here e_{FM} is the instantaneous amplitude of FM signal.

E_c is maximum amplitude of the signal.

ω_c is the carrier frequency.

ω_m is the modulating frequency.

and m_f is the modulating index of FM.

1.6 : Multiplexing Techniques

Q.9 What is TDM ? Draw and explain TDM multiplexing and demultiplexing process. [SPPU : May-18, 19, Marks 6]

Ans. : • In a Time Division Multiplexing (TDM) system, a single path and carrier frequency is used. TDM is a digital technology. Each user is assigned a unique time slot for their operation. A central switch, or multiplexer, goes from one user to the next in a specific, predictable sequence and time.

- TDM system can be applied when the data rate capacity of the transmission medium is greater than the data rate required by the sending and receiving devices. TDM is more efficient than FDM, in that it does not require guard bands and it operate directly in digital form.
- In TDM, the transmission between the multiplexers is provided by a single high speed digital transmission line. Each connection produce a digital information flow that is then inserted into the high speed line.
- A TDM system is a serial system, because the signal from each user follows, in time, the signal from another user. The overall bandwidth of the TDM result in much wider than the bandwidth of any individual user signal. This is because the TDM output is carrying much more information, and information requires bandwidth. The final bandwidth is approximately equal to the sum of the bandwidths of the individual signals.

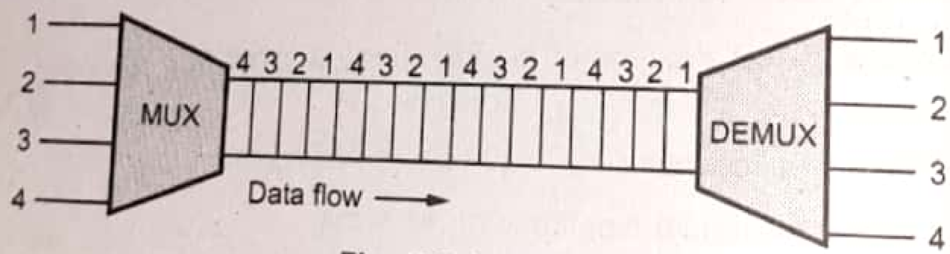


Fig. Q.9.1 TDM

- TDM is an alternative technique for splitting a big channel into many little channels. One modem would be used for the overall bandwidth W. Given m equal rate streams of binary data to be transmitted, the m bit streams would be multiplexed together into one bit stream. This is done by sending the data in successive frames. Each frame contains m slots, one for each bit stream to be multiplexed.
- The two basic forms of TDM are :
  1) Synchronous Time Division Multiplexing (STDM)
  2) Asynchronous Time Division Multiplexing (ASTDM) or statistical TDM (STATDM).

Q.10 Explain FDM multiplexing with their advantages and disadvantages. [SPPU : Dec.-19, Marks 6]

Ans. : • Frequency Division Multiplexing (FDM) is an analog multiplexing technique that combines analog signals.

- A number of signals can be carried simultaneously if each signal is modulated onto a different carrier frequency.
- In short, in FDM, the bandwidth is divided into a number of frequency slots, each of which can accommodate the signal of an individual connections.
- The most common examples of this are AM, FM and TV broadcasting, in which each station uses a different frequency band.
- An another example, voice grade channels are often frequency multiplexed together in the telephone network.
- In these examples, each multiplexed signal is limited to its own allocated frequency band to avoid interference with the other signals.
- FDM can be viewed as a technique for splitting a big channel into many little channels. Suppose that a physical channel has a usable bandwidth of m hertz and we wish to split it into n equal FDM subchannels, then each subchannel has m/n hertz available and thus m/n available quadrature samples per second for sending data.
- Fig. Q.10.1 shows the concept of FDM.

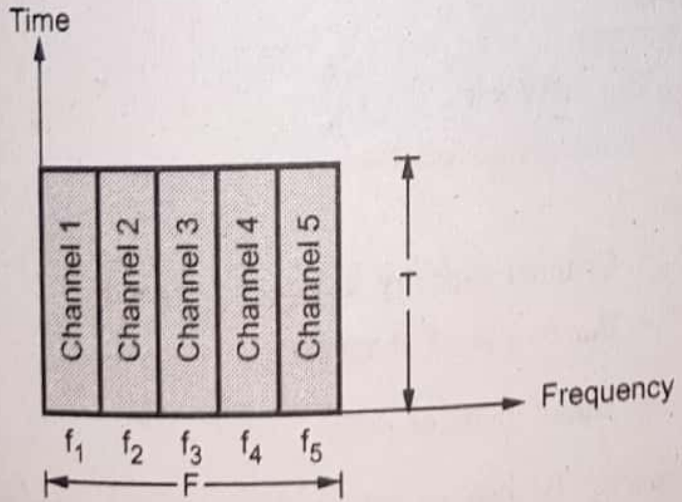


Fig. Q.10.1 Concept of FDM

- Fig. Q.10.2 illustrates FDM technique.

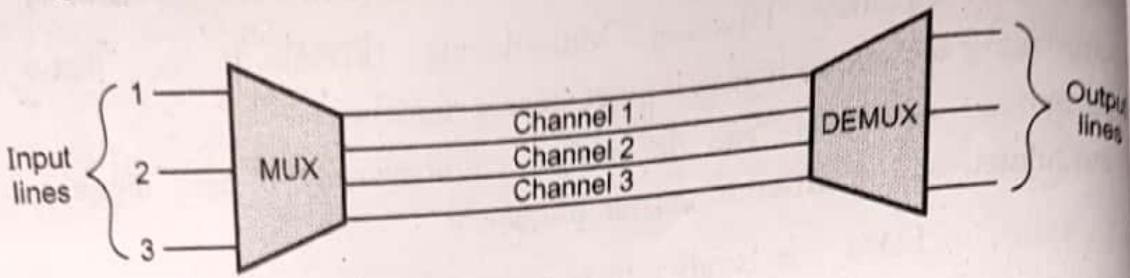


Fig. Q.10.2 FDM techniques

1.7 : Data Rate Limits

Q.11 Explain (i) Nyquist Bit Rate (ii) Shannon Capacity.

Ans. : (i) Nyquist bit rate

- Nyquist bit rate defines the theoretical maximum bit rate for a noiseless channel or ideal channel.

The formula for maximum bit rate in bits per second (bps) is :

$$\text{Maximum bit rate} = 2 \times BW \times \log_2 L$$

where, BW = Bandwidth at channel

L = Number of signal levels used to represent data.

(ii) Shannon capacity

- An ideal noiseless channel never exists. The maximum data rate for any noisy channel is :

$$C = BW \times \log_2\left(1 + \frac{S}{N}\right)$$

where,

C = Channel capacity in bits per second

BW = Bandwidth of channel

$\frac{S}{N}$ = Signal to noise ratio

The channel capacity is also called as Shannon capacity. The channel capacity do not depend upon the signal levels used to represent the data.

Q.12 Calculate the maximum bit rate of channel having bandwidth 1200 Hz if : i) S/N ratio is 0 dB ii) S/N ratio is 20 dB.

[SPPU : May-17, Marks 7]

Ans. :

$$BW = 1200 \text{ Hz}$$

i)

$$\mathbf{S/N = 0\ dB}$$

i.e.

$$0 = 10\log\left(\frac{S}{N}\right)$$

$$\frac{S}{N} = 1$$

Maximum bit rate

$$C = BW \times \log_2\left(1+\frac{S}{N}\right) = 1200 \times \log_2\left(1+\frac{S}{N}\right)$$

$$= 1200 \times \log_2(1+1)$$

$$= 1200 \times \left[\frac{\log_{10}(2)}{\log_{10}(2)}\right]$$

$$C = \mathbf{1200\ bits/sec.}$$ **... Ans.**

ii)

$$\mathbf{S/N = 20\ dB}$$

$$20 \text{ dB} = 10\log\left(\frac{S}{N}\right)$$

$$\frac{S}{N} = 100$$

$$C = BW \times \log_2\left(1+\frac{S}{N}\right)$$

$$= 1200 \times \log_2(1+100)$$

$$C = 1200 \times \left[\frac{\log_{10}(101)}{\log_{10}(2)}\right]$$

$$C = 7989.8$$

$$C \approx \mathbf{7990\ bits/sec.}$$ **...Ans.**

Q.13 The power of signal is 10 mW and the power of noise is 1 μW. What are the values of SNR and SNR_{dB} ? [SPPU : Dec.-17, Marks 6]

Ans. :

$$SNR = \frac{10\,mW}{1\,\mu W} = 10{,}000$$

$$SNR_{dB} = 10 \log SNR$$

$$SNR_{dB} = 10 \log (10{,}000)$$

$$= 40 \text{ dB}$$

...Ans.

1.8 : Topologies

Q.14 Explain: (i) Star topology (ii) Ring topology (iii) Mesh topology

Ans. : (i) Star topology

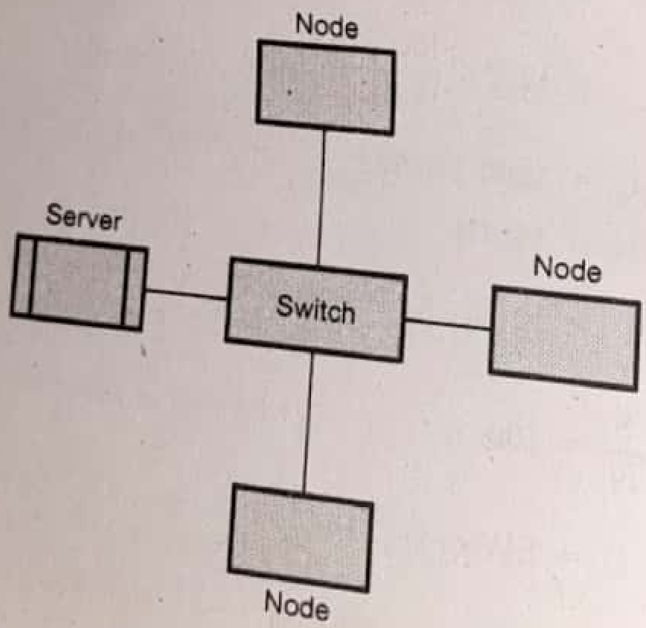


Fig. Q.14.1 Star topology

- A star topology consists of a number of devices connected by point-to-point links to a central hub.
- Easy to control and traffic flow is simple.
- Data travels from the sender to central hub and then to the receiver.

Advantages of star topology :

1) It is easy to modify and add new nodes to a star network without disturbing the rest of the network.
2) Troubleshooting techniques are easy.
3) Failures of any node do not bring down the whole star network.

Disadvantages of star network :

1) If the central hub fails, the whole network fails to operate.
2) Each device requires its own cable segment.
3) Installation can be moderately difficult, especially in the hierarchical network.

(ii) Ring topology

- In a ring topology, each computer is connected to the next computer, with the last one connected to the first. The signals travel on the cable in only one direction. Since each computer retransmits what it receives.
- Ring is an active network. Termination is not required.

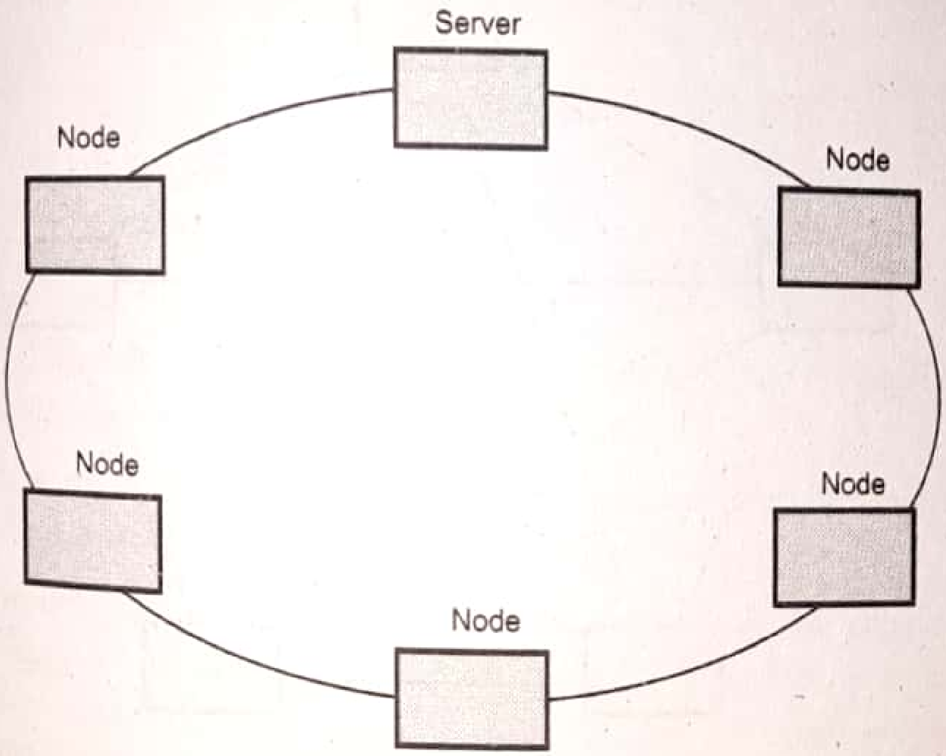


Fig. Q.14.2 Ring topology

Advantages of ring :

1) Cable failures are easily found.
2) Because every node is given equal access to the token, no one node can monopolize the network.

Disadvantages of ring :

1) Adding or removing nodes disrupts the network.
2) It is difficult to troubleshoot a ring network.
3) Failure of one node on the ring can affect the whole network.
4) Cost of cable is more in ring network.

(iii) Mesh topology

- The mesh topology has a link between each device in the network. It is more difficult to install as the number of devices increases.
- Mesh networks are easy to troubleshoot.
- Much of the bandwidth available in mesh configuration is wasted.
- Most mesh topology networks are not true mesh networks. Rather, they are hybrid mesh networks, which contain some most important sites with multiple links.

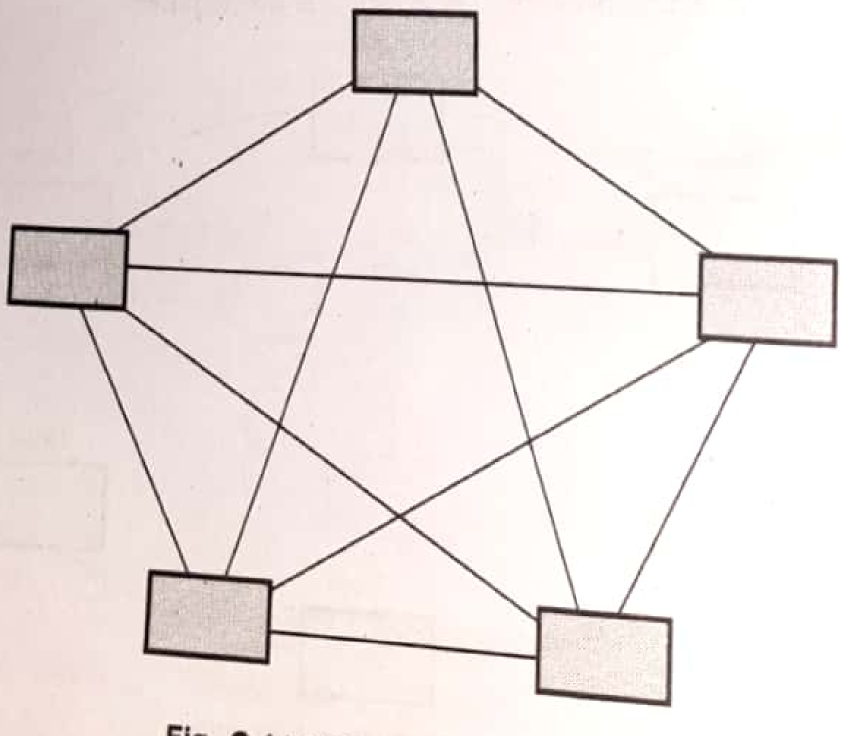


Fig. Q.14.3 True mesh topology

Advantages of Mesh :

1) Troubleshooting is easy. 2) Isolation of network failures is easy.

Disadvantages of mesh :

1) Difficulty of installation.
2) Costly because of maintaining redundant links.
3) Difficulty of reconfiguration.

1.9 : Noise

Q.15 Explain: (i) Thermal noise (ii) Intermodulation noise

Ans. : (i) Thermal noise

- Thermal noise is due to thermally agitated electrons in a conductor. As temperature increases more electrons and hence noise is generated.
- Since thermal noise is uniformally distributed across the frequency spectrum, therefore it is also called as **white noise.**
- Thermal noise is for bandwidth of W Hz is given by :

$$N = kTW$$

where,

k = Boltzmann's constant = 1.3803×10^{-23} J/°K

T = Temperature in Kelvin

N = Noise in watt

(ii) Intermodulation noise

- Intermodulation noise is generated when signals of different frequencies share the same transmission medium.
- Because of intermodulation noise, different frequencies are produced which are sum, difference and multiplication of two frequencies.
- Intermodulation of signals take place when there is component malfunction such as nonlinearity in transmitter, receiver or in repeater. Another cause of intermodulation noise is use of excessive signal strength.

1.10 : Network Models

Q.16 Draw ISO/OSI model and explain functions of the following layers :
1) Physical 2) Data link 3) Network layer. ☞ **[SPPU : Dec.-18, Marks 6]**

Ans. : OSI model : • The ISO was one of the first organizations to formally define a common way to connect computers. Their architecture, called the Open System Interconnection (OSI).

- The International organization for standardization developed the **Open System Interconnection (OSI)** reference model. OSI model is the most widely used model for networking.
- OSI model is a seven layer standard.
- The OSI model does not specify the communication standard or protocols to be used to perform networking tasks.
- OSI model provides following services.
  1) Provides peer-to-peer logical services with layer physical implementation.
  2) Provides standards for communication between system.
  3) Defines point of interconnection for the exchange of information between system.
  4) Each layer should perform a well defined function.
  5) Narrows the options in order to increase the ability to communicate without expansive conversions and translations between products.

Principles in defining OSI layers

- Following principles are used in defining the OSI layers.
  1. Do not create so many layers as to make the system engineering task of describing and integrating the layers more difficult than necessary.
  2. Create a boundary at a point where the description of services can be small and the number of interrelations across the boundary are minimized.
  3. Create separate layers to handle function that are manifestly different in the process performed.

4. Collect similar functions into the same layer.
5. Select the boundaries at a point which past experience has demonstrated to be successful.
6. Create a layer of easily localized functions so that the layer could be totally redesigned and its protocols changed in a major way to take advantage of new advances in architecture, hardware or software technology without changing the services expected from and provided to the adjacent layers.
7. Create a boundary where it may be useful at some points in time to have the corresponding interface standardized.
8. Create a layer where there is a need for a different level of abstraction in the handling of data.
9. Allow changes of functions or protocols to be made within a layer without affecting other layers.
10. Create for each layer boundaries with its upper and lower layer only.

- Fig. Q.16.1 shows the OSI 7 layer reference model.

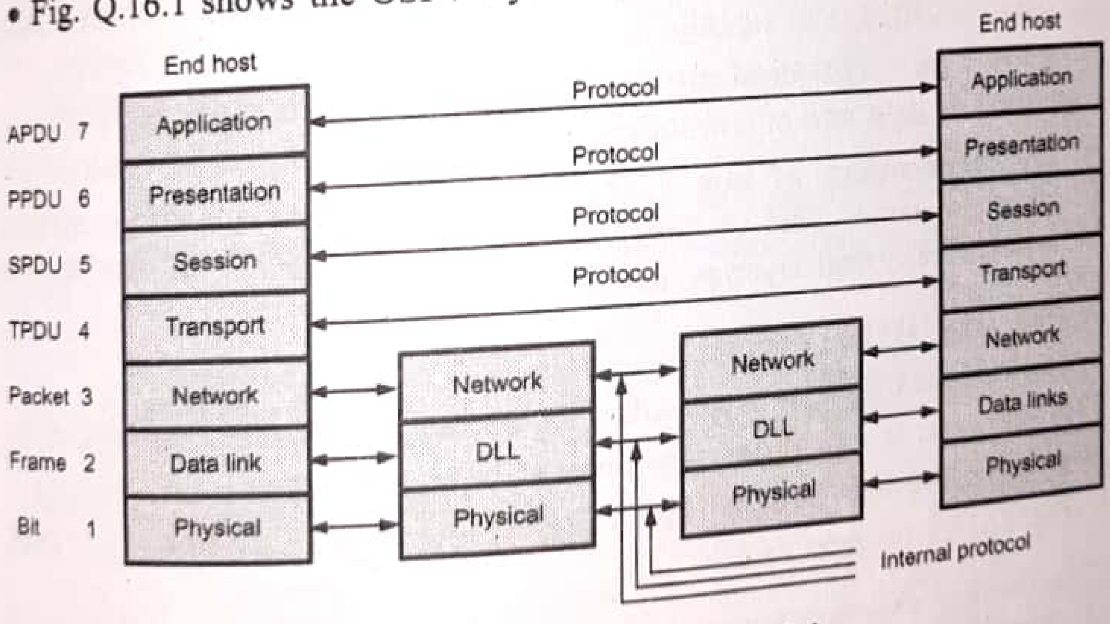


Fig. Q.16.1 Layer of OSI model

Layers in OSI Models

1. Physical layer

- Physical layer is the lowest layer of the OSI model. Physical layer co-ordinates the functions required to transmit a bit stream over a communication channel. It deals with electrical and mechanical specifications of interface and transmission media. It also deals with procedures and functions required for transmission.

- The position of physical layer with transmission medium and the next layer (data link layer) is shown in Fig. Q.16.2.

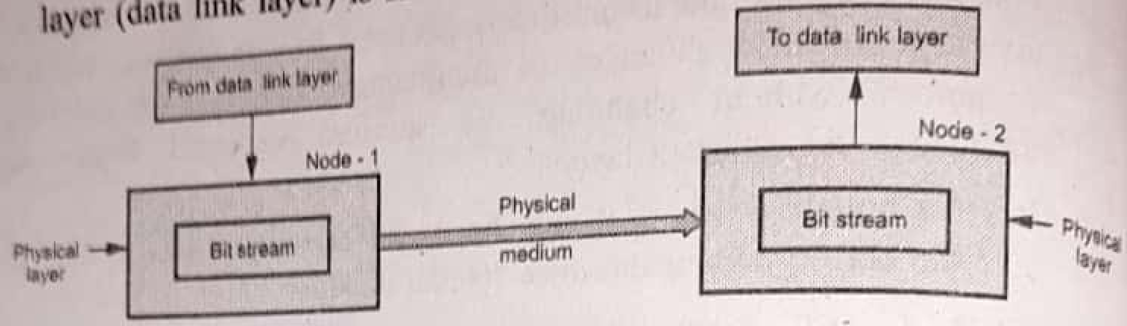


Fig. Q.16.2 Physical layer

Functions of Physical Layer

1. **Physical characteristics of interfaces and media :** The design issue of physical layer considers the characteristics of interface between devices and transmission media.
2. **Representation of bits :** Physical layer encodes the bit stream into electrical or optical signal.
3. **Data rate :** The physical layer defines the duration of a bit which is called as data rate or transmission rate.
4. **Synchronization of bits :** The transmission rate and receiving rate must be same. This is done by synchronizing clocks at sender and receiver. Physical layer performs this function.

2. Data link layer

- The data link layer is responsible for transmitting frames from one node to the next. It transforms the physical layer to a reliable link making it an error free link to upper layer. Fig. Q.16.3 shows data link layer. (See Fig. Q.16.3 on next page)

Functions of data link layer

1. **Framing :** The frames received from network layer is divided into manageable data units called frames.
2. **Physical addressing :** When frames are to be sent to different LANs, the data link layer adds a header to the frame to define sender or receiver.
3. **Flow control :** When the rate of the data transmitted and rate of data reception by receiver is not same, some data may be lost. The data

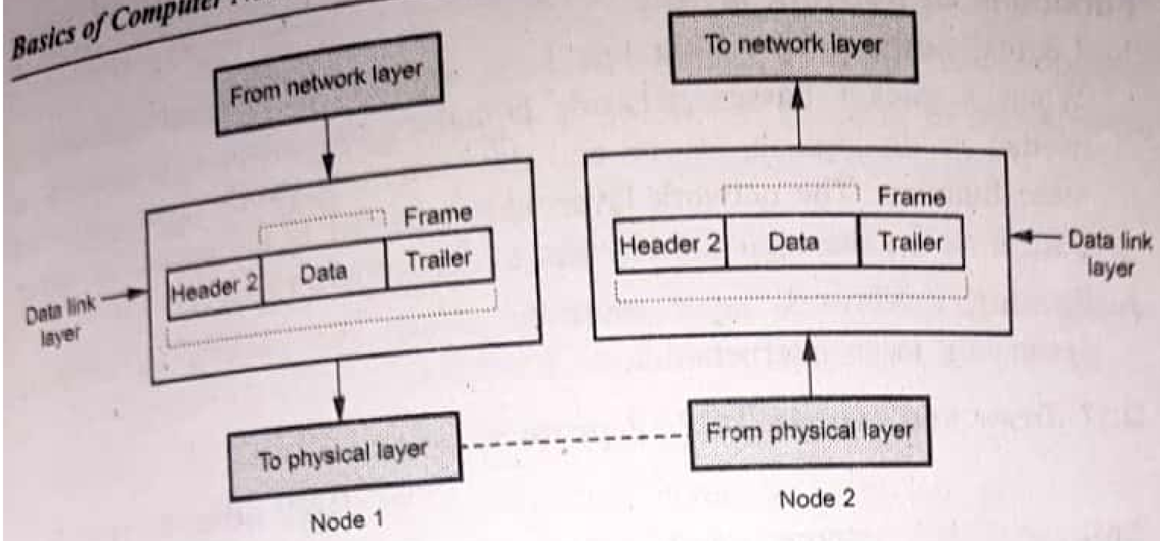


Fig. Q.16.3 Data link layer

link layer imposes a flow control mechanism to prevent overwhelming the receiver.

4. **Error control :** Data link layer incorporates reliability to the physical layer by adding mechanism to detect and retransmit damaged or lost frames.
5. **Access control :** When multiple devices are connected to same link, the data link layer determines which device has control over link.

3. Network layer :

- The network layer is responsible for the delivery of packets from the source to destination. Fig. Q.16.4 shows network layer.

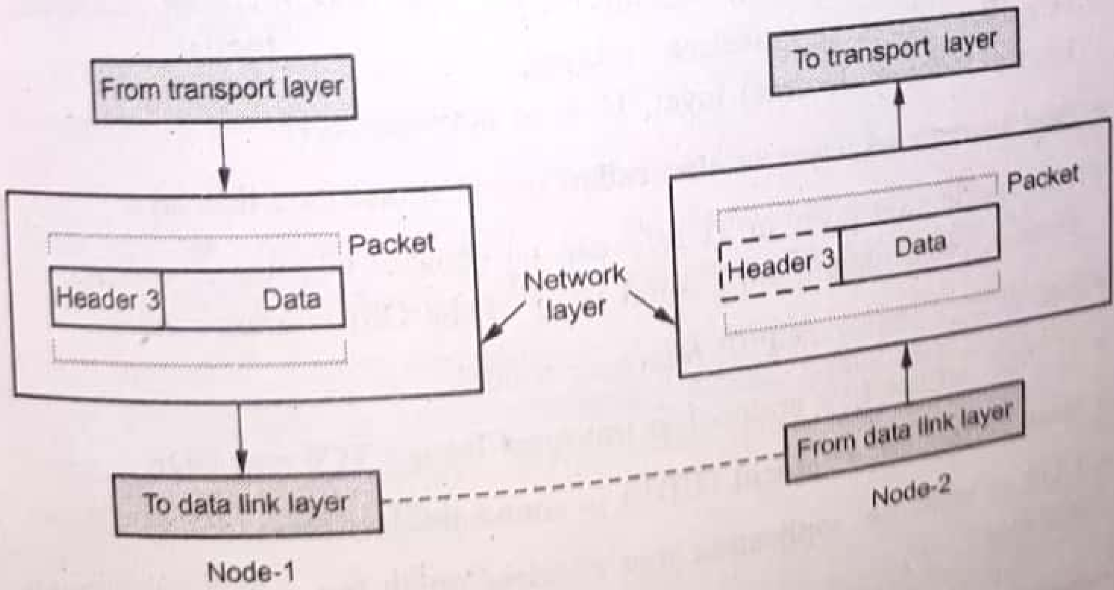


Fig. Q.16.4 Network layer

Functions of network layer

1. **Logical addressing :** Data link layer implements physical addressing. When a packet passes network boundary, an addressing system is needed to distinguish source and destination, network layer performs these function. The network layer adds a header to the packet of upper layer includes the logical addresses of sender and receiver.
2. **Routing :** Network layer route or switch the packets to its final destination in an internetwork.

Q.17 Draw and explain TCP/IP protocol suite. [SPPU : May-18, Marks 6]

Ans. : • The internet architecture, which is also sometimes called the TCP/IP architecture after its two main protocols.

- TCP/IP stands for Transmission Control Protocol / Internet Protocol.
- The TCP/IP reference model is a set of protocols that allow communication across multiple diverse networks.

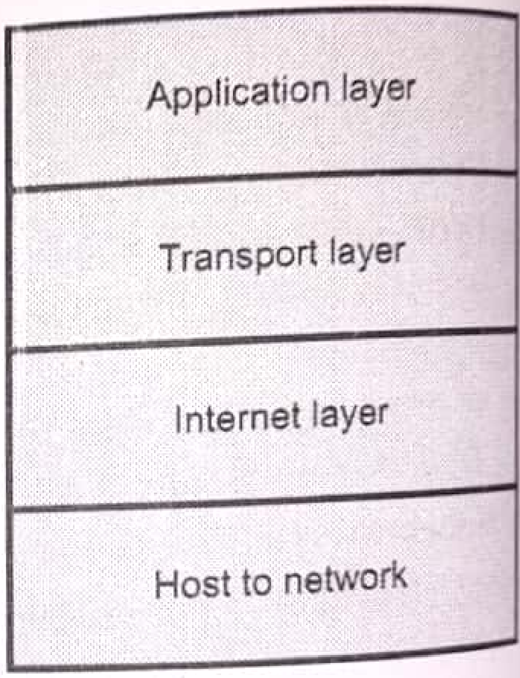


Fig. Q.17.1 TCP/IP reference model

- TCP/IP is normally considered to be a four layer system. Layers of TCP/IP are Application layer, Transport layer, Internet layer, Host to network layer.
- Host to network layer is also called physical and data link layer.
- The application layer in TCP/IP can be equated with the combination of session, presentation, application layer of the OSI reference model.
- Fig. Q.17.1 shows TCP/IP reference model.
- TCP/IP defines two protocol at transport layer : TCP and UDP.
- **User Datagram Protocol (UDP)** is connectionless protocol.
- UDP is used for application that requires quick but necessarily reliable delivery.

- Internet layer also called **network layer.** Internet layer handles communication from one machine to the other. Routing of packet takes place in internet layer.
- TCP/IP does not define any specific protocol in host to network layer. This layer is responsible for accpeting and transmitting IP datagrams. This layer normally includes the device driver in the operating system.
- Detailed function of each layer is given below.
  1. **Application layer :** Application layer includes all process and services that use the transport layer to deliver data. The most widely known application protocols are : TELNET, File Transfer Protocol (FTP), Simple Mail Transfer Protocol (SMTP) and Simple Network Management Protocol (SNMP). TELNET is the Network Terminal Protocol, which provides remote login over the network. FTP is used for interactive file transfer. SMTP delivers the electronic mail.
  2. **Transport layer :** Application programs send data to the transport layer protocols TCP and UDP. An application is designed to choose either TCP or UDP based on the services it needs.
- The transport layer provides peer entities on the source and destination hosts to carry on a conversation. Both ends protocol is defined in this layer.
- TCP is reliable connection oriented protocol that allows a byte stream originating on one computer to be delivered without error or any other computer in the internet.
- It converts the incoming byte stream into discrete message and passes each one onto the internet layer. At the destination side, the receiving TCP reassembles the received data or messages into the output format.
- TCP also handles flow control. It synchronizes between fast sender and slow receiver. UDP is a connectionless protocol. Sometimes this type of protocol is used for prompt delivery. The relation of the protocols is shown in the Fig. Q.17.2.

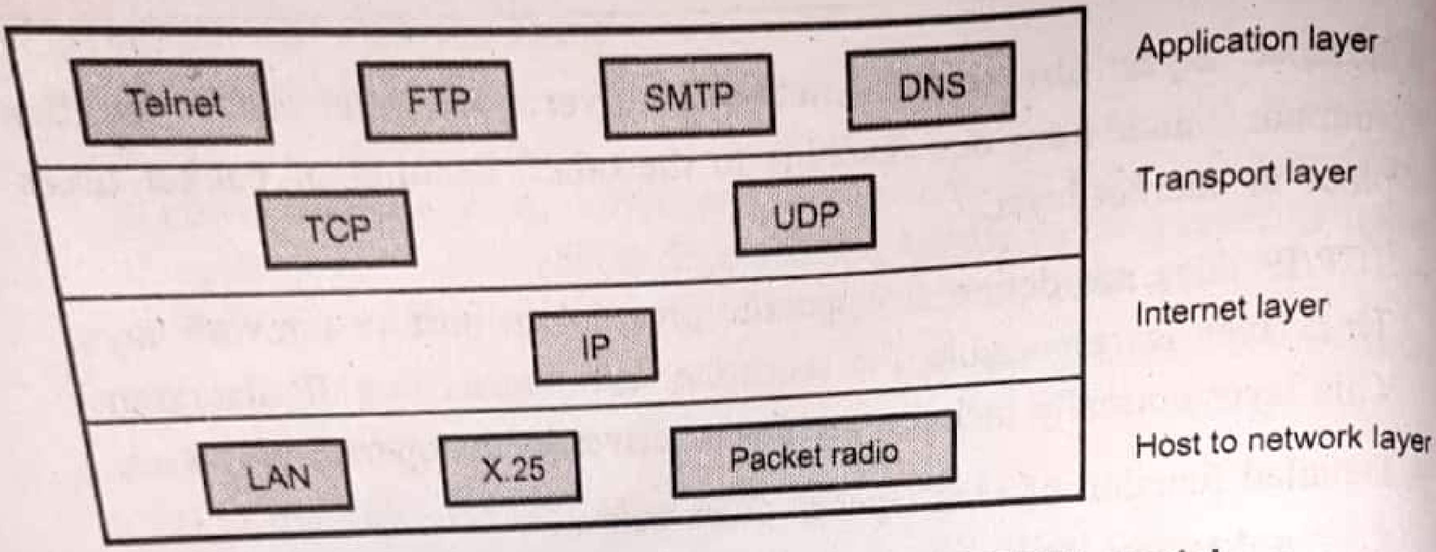


Fig. Q.17.2 Relation of protocol in TCP/IP model

3. **Internet layer :** The Internet network level protocol (IP, ARP, ICMP) handle machine to machine communications.

- These protocols provide for transmission and reception of transport requests and handle network level control. The TCP/IP internet layer moves data from one host to another; even if the hosts are on different networks. The primary protocol used to move data is the Internet Protocol (IP), which provides the following services :

  a. **Addressing :** Determining the route to deliver data to the destination host.

  b. **Fragmentation :** Breaking the messages into pieces if an intervening network cannot handle a large message.

- It provides a connectionless method of delivering data from one host to another. It does not guarantee delivery and does not provide sequencing of datagrams. It attaches a header to datagram that includes source address and the destination address, both of which are unique internet addresses.

4. **Host to network :** This layer is also called network interface layer. This layer is same as **physical and data link layer of OSI model. Host to network layer cannot define any protocol.** It is responsible for accpeting and transmitting IP datagrams. This layer may consist of a device driver in the operating system and the corresponding network interface card in the machine.

1.11 : Addressing

Q.18 Explain with examples different addressing schemes used in TCP/IP. [SPPU : May-17, Dec.-18, 19, Marks 6]

Ans. : • An Internet employing TCP/IP protocols uses four levels of addresses :

1. Physical (Link) addresses
2. Logical (IP) addresses
3. Port addresses
4. Specific addresses

• Each address type is related to a specific layer in TCP/IP architecture. Fig. Q.18.1. shows the relationship of layers and addresses in TCP/IP.

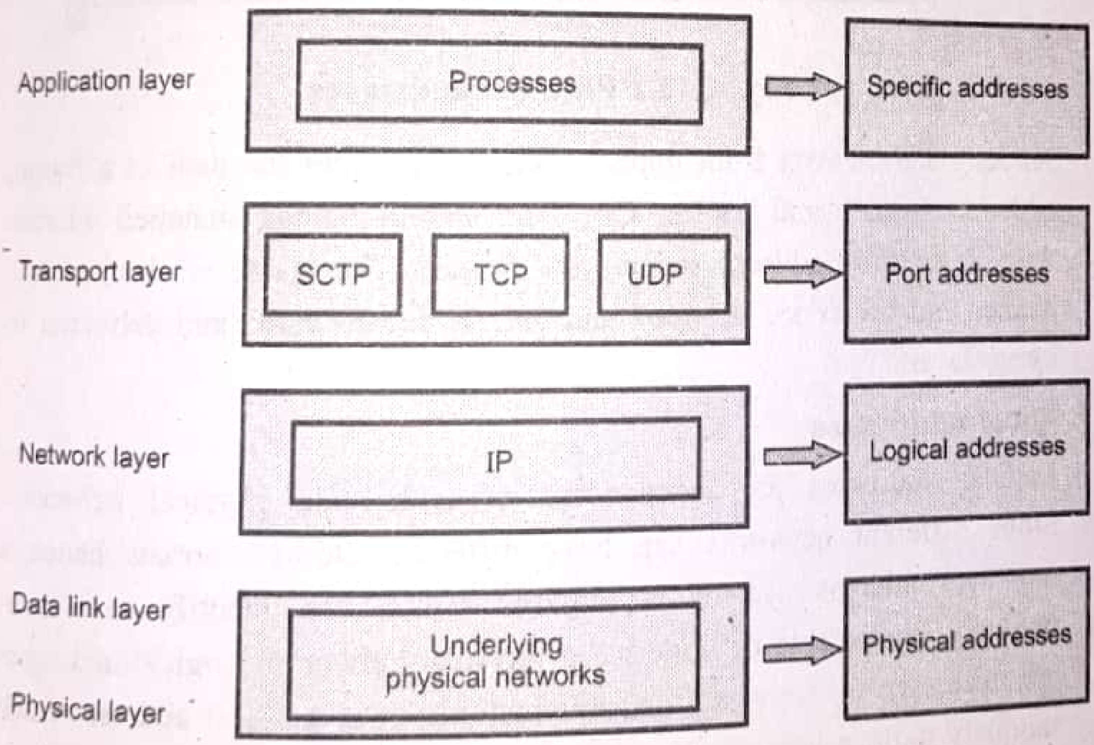


Fig. Q.18.1 TCP/IP layers and associated addresses

Physical addresses

• The physical address is the lowest level address and is also referred as link address. The physical address of a node is defined by its LAN or WAN. The physical address is included in the frame by the data link layer.

• The size and format of physical addresses vary depending on the network. It has authority over the network. At data link layer the frame contains physical (link) addresses in the header. The data link layer at

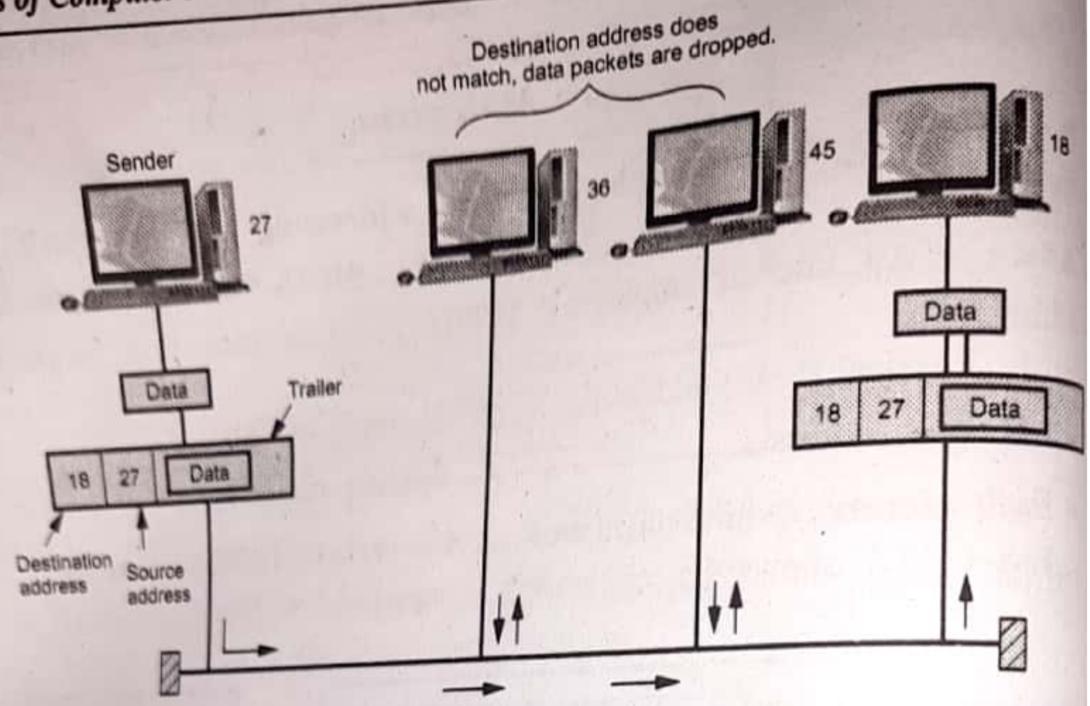


Fig. Q.18.2 Physical addresses

sender receives data from upper layer, encapsulates the data in a frame, adds an header and trailer. Only the station having matched address with destination address accepts the frames. The frame is checked, the header and trailer are dropped and data is decapsulated and delivered to upper layer.

Logical addresses

- Logical addresses are independent of underlying physical networks. Since different networks can have different address formats hence a universal address system is required which can identify each host uniquely irrespective of underlying physical networks. Logical addresses are necessary for universal communications. It is a 32-bit address which uniquely defines host connected to Internet.
- The physical addresses changes from hop to hop, but the logical address usually remains the same.

Port addresses

- The IP address and physical address are necessary for data to travel from source to destination. But a communication process involves TELNET and FTP which requires addresses. In TCP/IP architecture, the label assigned to a process is called port address. In TCP/IP the port address is of 16-bit.

Specific addresses

- Specific addresses are designed by users for some applications. For example, evilaas@in.com and the Universal Resource Locator (URL), www.vtubooks.com. The first example defines the recipient of e-mail and second example is used to find a document on the world wide web.
- The specific addresses gets changed to corresponding port and logical addresses by the station or host who sends it.

END...