Data Communications

Solutions for IAT-1 Questions

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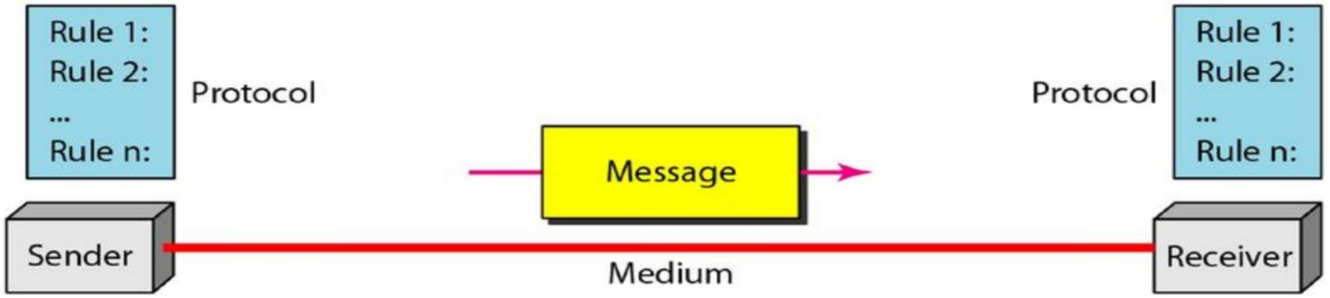
Q1. What are the different components required for comprising a Data Communication system? What types of data flow modes it supports?

A data communications system has five components.



Message: The message is the information (data) to be communicated. Popular forms of information include text, numbers, pictures, audio, and video.

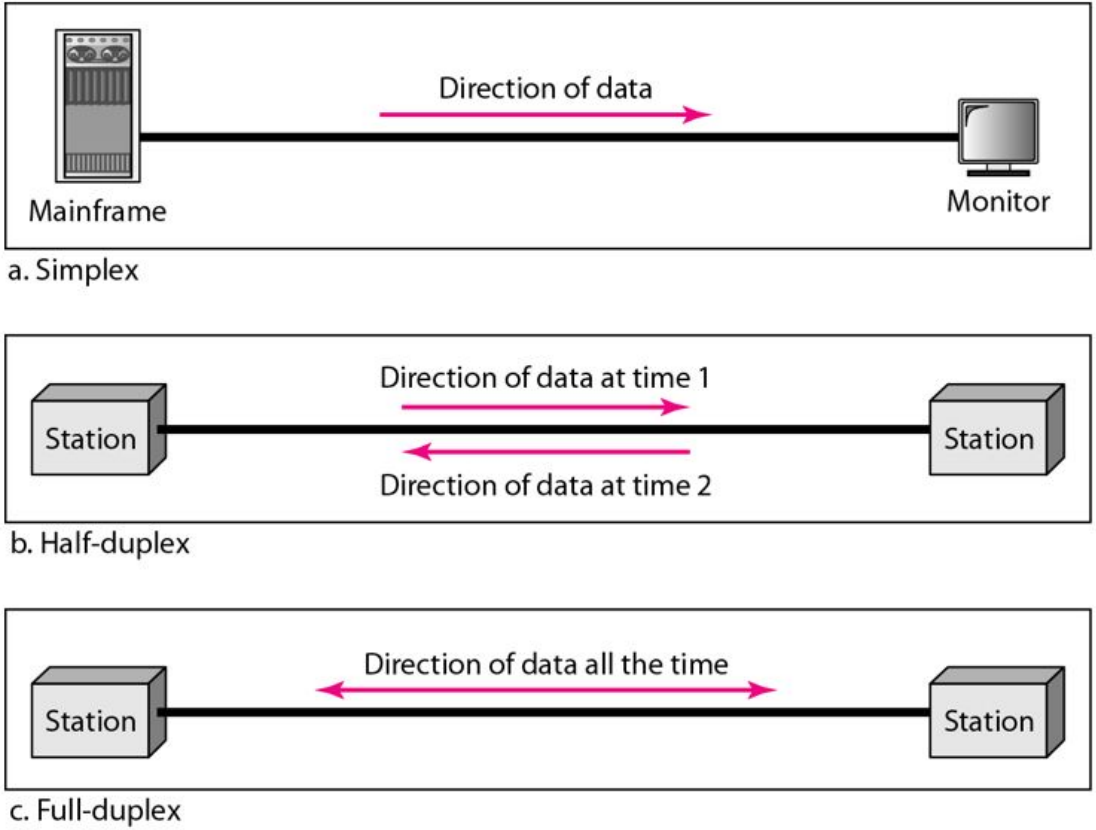
Sender: The sender is the device that sends the data message. It can be a computer, workstation, telephone handset, video camera, and so on.

Receiver: The receiver is the device that receives the message. It can be a computer, workstation, telephone handset, television, and so on.

Transmission medium: The transmission medium is the physical path by which a message travels from sender to receiver. Some examples of transmission media include twisted-pair wire, coaxial cable, fiber-optic cable, and radio waves.

Protocol. A protocol is a set of rules that govern data communications. It represents an agreement between the communicating devices. Without a protocol, two devices may be connected but not communicating, just as a person speaking French cannot be understood by a person who speaks only Japanese.

Data Flow Modes:Communication between two devices can be simplex, half-duplex, or full-duplex as shown in Figure below.



Simplex mode: In simplex mode, the communication is unidirectional, as on a one-way street. Only one of the two devices on a link can transmit; the other can only receive (see Figure 1.2a). Keyboards and traditional monitors are examples of simplex devices. The keyboard can only introduce input; the monitor can only accept output. The simplex mode can use the entire capacity of the channel to send data in one direction.

Half-Duplex: In half-duplex mode, each station can both transmit and receive, but not at the same time. : When one device is sending, the other can only receive, and vice versa (see Figure 1.2b).

The half-duplex mode is like a one-lane road with traffic allowed in both directions. When cars are traveling in one direction, cars going the other way must wait. In a half-duplex transmission, the entire capacity of a channel is taken over by whichever of the two devices is transmitting at the time. Walkie-talkies and CB (citizens band) radios are both half-duplex systems. The half-duplex mode is used in cases where there is no need for communication in both directions at the same time; the entire capacity of the channel can be utilized for each direction.

In full-duplex mode, both stations can transmit and receive simultaneously (see Figure 1.2c).

One common example of full-duplex communication is the telephone network. When two people are communicating by a telephone line, both can talk and listen at the same time. The full-duplex mode is used when communication in both directions is required all the time. The capacity of the channel, however, must be divided between the two directions.

Q2. a). A file contains 2 million bytes. How long does it take to download this file using a 56-Kbps channel? 1-Mbps channel?

b). Differentiate between Baseband and Broadband transmissions.

a).

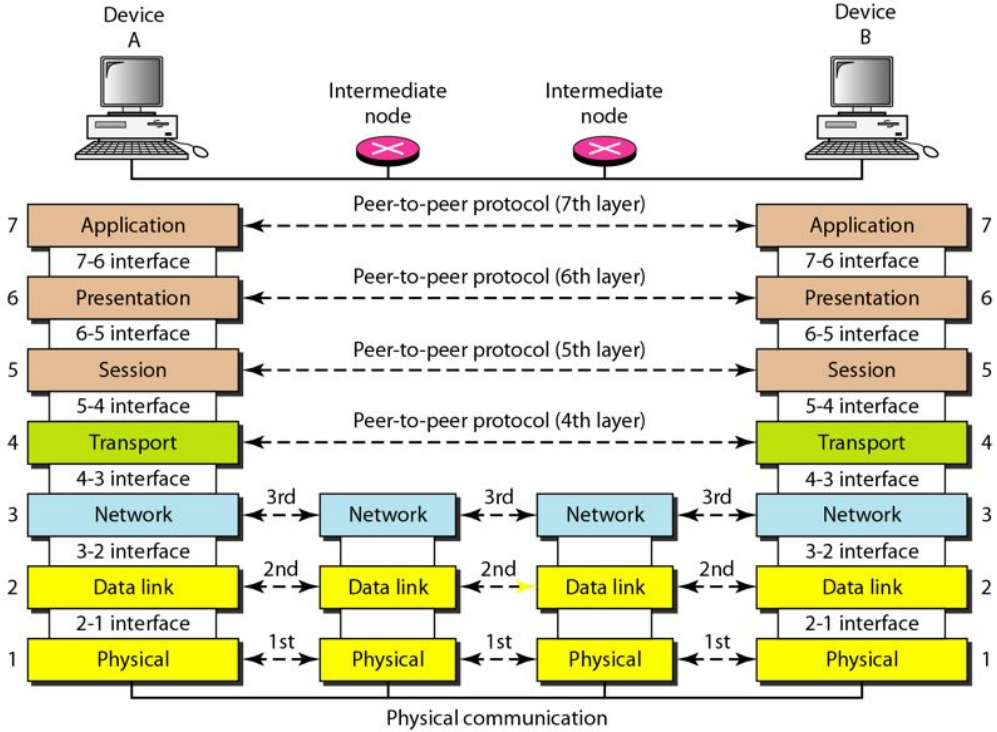
The file contains $2{,}000{,}000 \times 8 = 16{,}000{,}000$ bits. With a 56-Kbps channel, it takes $16{,}000{,}000/56{,}000 =$ **289 s**. With a 1-Mbps channel, it takes **16 s**.

b). Difference between Baseband and Broadband Transmissions:

	BASEBAND	BROADBAND
DETAILS	Baseband Transmission is a transmission technique that one signal requires the entire bandwidth of the channel to send data.	Broadband transmission is a transmission technique that many signals with multiple frequencies transmit data through a single channel simultaneously.
TYPE OF SIGNAL?	Digital signals	Analog signals
TRANSMISSION?	Bidirectional. - Baseband transmission uses digital signals to send data through the media as a single channel. One signal takes the entire bandwidth of the network media for transmission.	Unidirectional. - Data transmission happens only to a one direction at a time. Therefore, in broadband transmission, it can only send or receive but cannot do both simultaneously.
MUKLTIPLEXING TECHNIQUE?	Baseband transmission utilizes Time Division Multiplexing (TDM).	Broadband transmission use Frequency Division Multiplexing (FDM).
NUMBER OF SIGNAL ?	Sends one signal at a time	Sends multiple signals simultaneously
SIGNAL RANGE	Signals travel a short distance	Signals travel a long distance without much attenuation
FILTER?	Low-pass filter.	Bandpass filter.
EXAMPLE?	Ethernet is an example	Cable TV, Wi-Fi, and Power Line communication are some examples

Q3. Explain OSI Reference Model

Ans: The OSI model is composed of seven ordered layers. Figure given below shows the layers involved when a message is sent from device A to device B. As the message travels from A to B, it may pass through many intermediate nodes. These intermediate nodes usually involve only the first three layers of the OSI model.



Physical Layer:The lowest layer of the OSI reference model is the physical layer. It is responsible for the actual physical connection between the devices. The physical layer contains information in the form of **bits.** It is responsible for transmitting individual bits from one node to the next.

The functions of the physical layer are as follows:

1. **Bit synchronization:** The physical layer provides the synchronization of the bits by providing a clock. This clock controls both sender and receiver thus providing synchronization at bit level.
2. **Bit rate control:** The Physical layer also defines the transmission rate i.e. the number of bits sent per second.
3. **Physical topologies:** Physical layer specifies the way in which the different, devices/nodes are arranged in a network i.e. bus, star, or mesh topology.
4. **Transmission mode:** Physical layer also defines the way in which the data flows between the two connected devices. The various transmission modes possible are Simplex, half-duplex and full-duplex.

Data Link Layer (DLL) (Layer 2) :

The data link layer is responsible for the node-to-node delivery of the message. The main function of this layer is to make sure data transfer is error-free from one node to another, over the physical layer.

The functions of the Data Link layer are :

1. **Framing: Framing is a function of the data link layer. It provides a way for a sender to transmit a set of bits that are meaningful to the receiver. This can be accomplished by attaching special bit patterns to the beginning and end of the frame.**
2. **Physical addressing: After creating frames, the Data link layer adds physical addresses (MAC address) of the sender and/or receiver in the header of each frame.**
3. **Error control: Data link layer provides the mechanism of error control in which it detects and retransmits damaged or lost frames.**
4. **Flow Control: The data rate must be constant on both sides else the data may get corrupted thus, flow control coordinates the amount of data that can be sent before receiving acknowledgement.**
5. **Access control: When a single communication channel is shared by multiple devices, the MAC sub-layer of the data link layer helps to determine which device has control over the channel at a given time.**

Network Layer (Layer 3) :

The network layer works for the transmission of data from one host to the other located in different networks. It also takes care of packet routing i.e. selection of the shortest path to transmit the packet, from the number of routes available. The sender & receiver's IP addresses are placed in the header by the network layer.

The functions of the Network layer are :

1. **Routing: The network layer protocols determine which route is suitable from source to destination. This function of the network layer is known as routing.**
2. **Logical Addressing: In order to identify each device on internetwork uniquely, the network layer defines an addressing scheme. The sender & receiver's IP addresses are placed in the header by the network layer. Such an address distinguishes each device uniquely and universally.**

Transport Layer (Layer 4) :

The transport layer provides services to the application layer and takes services from the network layer. The data in the transport layer is referred to as *Segments*. It is responsible for the End to End Delivery of the complete message.

The functions of the transport layer are as follows:

1. **Segmentation and Reassembly: This layer accepts the message from the (session) layer, and breaks the message into smaller units. Each of the segments produced has a header associated with it. The transport layer at the destination station reassembles the message.**
2. **Service Point Addressing: In order to deliver the message to the correct process, the transport layer header includes a type of address called service point address or port address. Thus by specifying this address, the transport layer makes sure that the message is delivered to the correct process.**
3. **Error Control: Uses Checksum method for detecting the transmission errors at the receiver end.**
4. **Flow Control: Uses the flow control Protocols to control the data flow from fast sender to the receiver.**

Session Layer (Layer 5) :

This layer is responsible for the establishment of connection, maintenance of sessions, authentication, and also ensures security.

The functions of the session layer are :

1. **Session establishment, maintenance, and termination: The layer allows the two processes to establish, use and terminate a connection.**
2. **Synchronization: This layer allows a process to add checkpoints which are considered synchronization points into the data. These synchronization points help to identify the error so that the data is re-synchronized properly, and ends of the messages are not cut prematurely and data loss is avoided.**
3. **Dialog Controller: The session layer allows two systems to start communication with each other in half-duplex or full-duplex.**

Presentation Layer (Layer 6):

The presentation layer is also called the Translation layer. The data from the application layer is extracted here and manipulated as per the required format to transmit over the network.

The functions of the presentation layer are :

- **Translation: For example, ASCII to EBCDIC.**
- **Encryption/ Decryption: Data encryption translates the data into another form or code. The encrypted data is known as the ciphertext and the decrypted data is known as plain text. A key value is used for encrypting as well as decrypting data.**
- **Compression: Reduces the number of bits that need to be transmitted on the network.**

Application Layer (Layer 7) :

At the very top of the OSI Reference Model stack of layers, we find the Application layer which is implemented by the network applications. These applications produce the data, which has to be transferred over the network. This layer also serves as a window for the application services to access the network and for displaying the received information to the user.

Example: Application — Browsers, Skype Messenger, etc.

Q4. **Draw the graph of the NRZ-L and Manchester scheme using each of the following data streams, assuming that the last signa1level has been positive. Based on the plotted graph, discuss the following characteristics.**

- **i) Baseline wandering**
- **ii) Self-synchronization**
- **iii) Existence of DC Component**

Data stream: 100101011100110

5 a). Explain the important characteristics of line coding.

- Signal Element Versus Data Element:A data element is the smallest entity that can represent a piece of information: this is the bit. In digital data communications, a signal element carries data elements. A signal element is the shortest unit (timewise) of a digital signal. In other words, data elements are what we need to send; signal elements are what we can send. Data elements are being carried; signal elements are the carriers.
- Data Rate Versus Signal Rate The data rate defines the number of data elements (bits) sent in Is. The unit is bits per second (bps). The signal rate is the number of signal elements sent in Is. The unit is the baud. goal in data communications is to increase the data rate while decreasing the signal rate. Increasing the data rate increases the speed of transmission; decreasing the signal rate decreases the bandwidth requirement.
- Baseline Wandering In decoding a digital signal, the receiver calculates a running average of the received signal power. This average is called the baseline. The incoming signal power is evaluated against this baseline to determine the value of the data element. A long string of Os or 1s can cause a drift in the baseline (baseline wandering) and make it difficult for the receiver to decode correctly. A good line coding scheme needs to prevent baseline wandering.

- **DC Components** When the voltage level in a digital signal is constant for a while, the spectrum creates very low frequencies (results of Fourier analysis). These frequencies around zero, called DC (direct-current) components, present problems for a system that cannot pass low frequencies or a system that uses electrical coupling (via a transformer). For example, a telephone line cannot pass frequencies below 200 Hz. Also a long-distance link may use one or more transformers to isolate different parts of the line electrically. For these systems, we need a scheme with no DC component.
- **Self-synchronization** To correctly interpret the signals received from the sender,the receiver's bit intervals must correspond exactly to the sender's bit intervals. If the receiver clock is faster or slower, the bit intervals are not matched and the receiver might misinterpret the signals.

Built-in Error Detection It is desirable to have a built-in error-detecting capability in the generated code to detect some of or all the errors that occurred during transmission. Some encoding schemes that we will discuss have this capability to some extent.

Immunity to Noise and Interference Another desirable code haracteristic is a code I that is immune to noise and other interferences. Some encoding schemes that we will discuss have this capability.

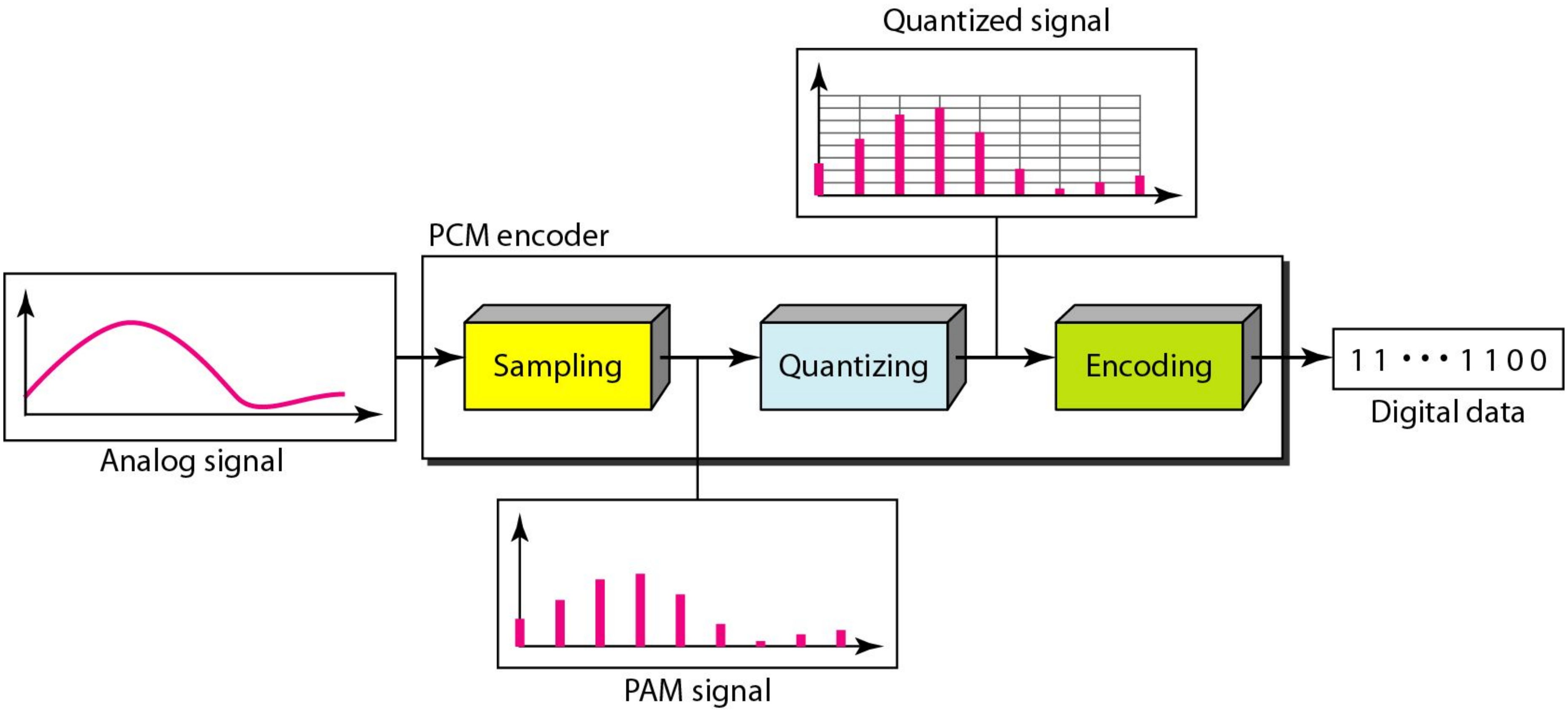
Complexity A complex scheme is more costly to implement than a simple one. For example, a scheme that uses four signal levels is more difficult to interpret than one that uses only two levels.

5 b). A signal has passed through three cascaded amplifiers, each with a 4 dB gain. What is the total gain?

Ans: 12Db (The amplifiers are connected in Series.

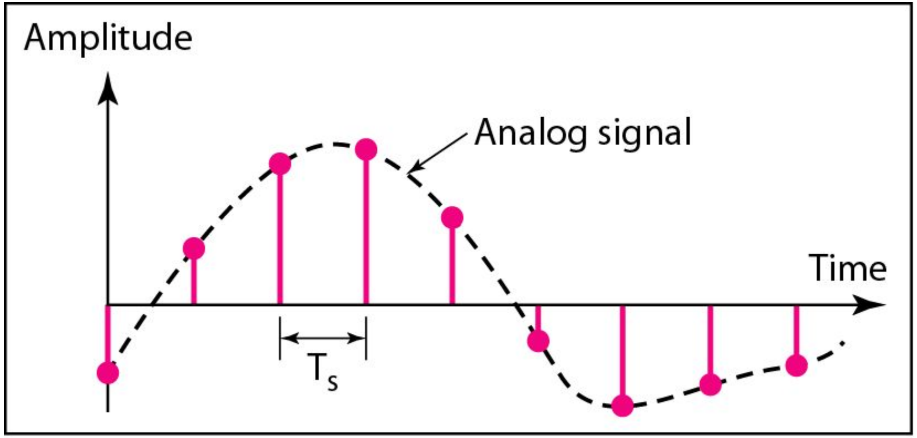
Q6.Design PCM encoding and decoding schemes

- PCM consists of three steps to digitize an analog signal:
    1. Sampling
    2. Quantization
    3. Binary encoding
- Before we sample, we have to filter the signal to limit the maximum frequency of the signal as it affects the sampling rate.
- Filtering should ensure that we do not distort the signal, ie remove high frequency components that affect the signal shape.

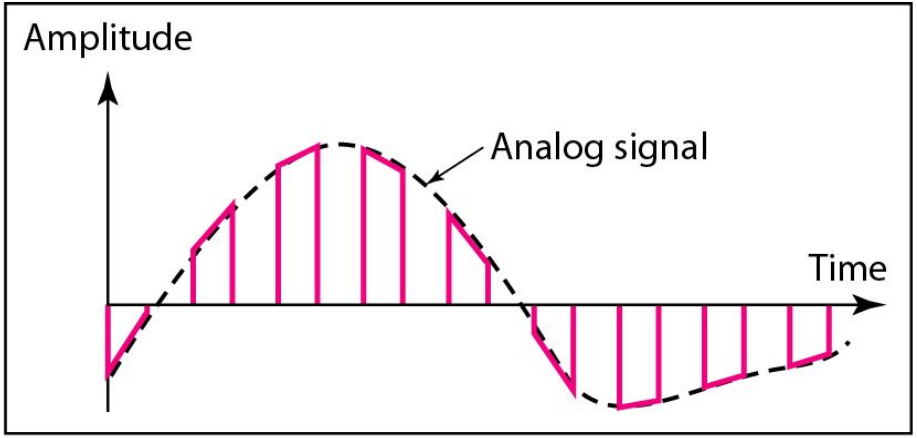

Quantized signal
PCM encoder
Sampling
Quantizing
Encoding
1 1 • • • 1 1 0 0
Digital data
Analog signal
PAM signal

Sampling

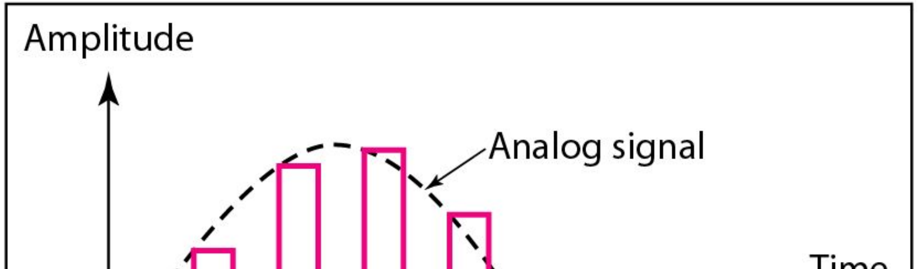
- Analog signal is sampled every T_S secs.
- T_s is referred to as the sampling interval.
- $f_s = 1/T_s$ is called the sampling rate or sampling frequency.
- There are 3 sampling methods:
  - Ideal - an impulse at each sampling instant
  - Natural - a pulse of short width with varying amplitude
  - Flattop - sample and hold, like natural but with single amplitude value
- The process is referred to as pulse amplitude modulation PAM and the outcome is a signal with analog (non integer) values



a. Ideal sampling



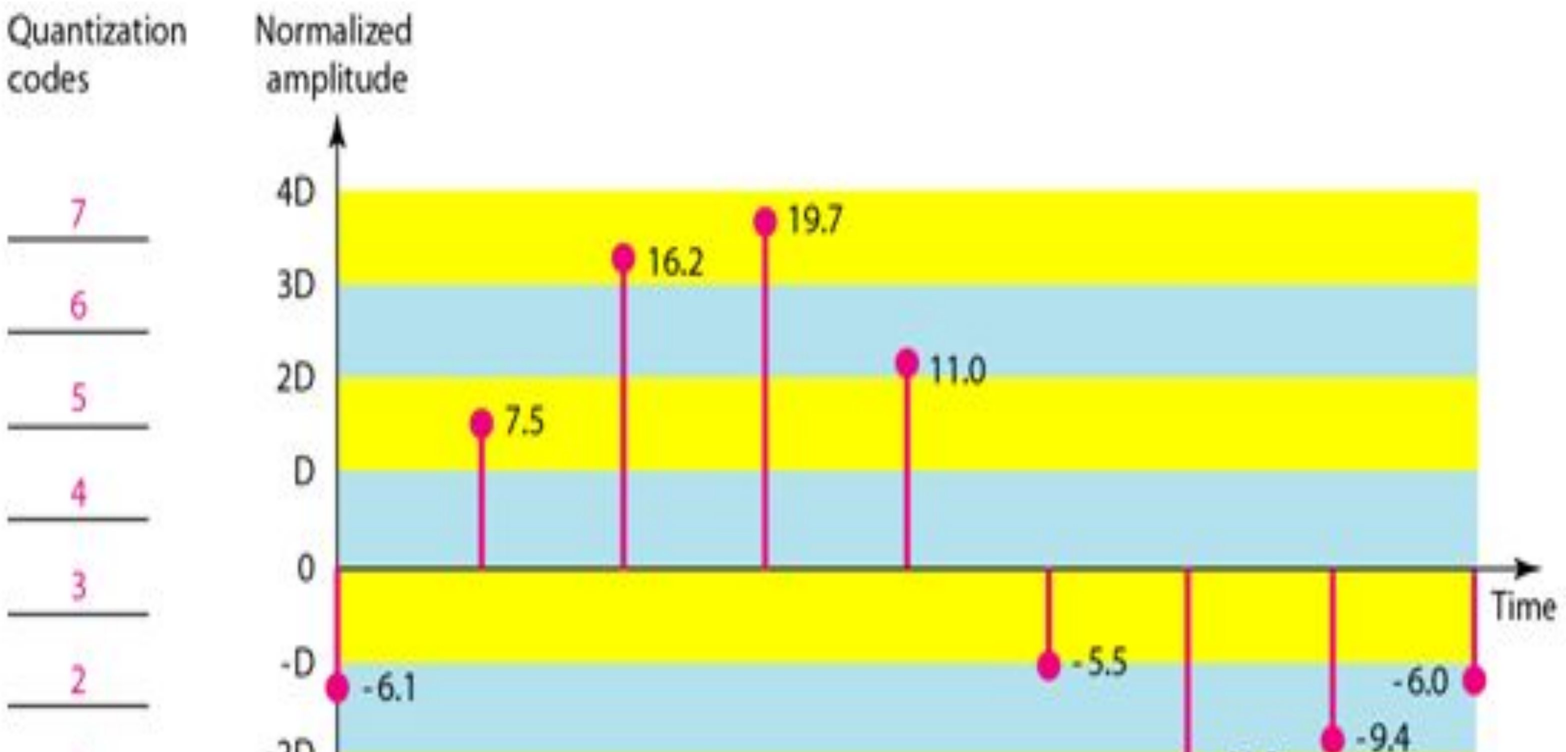
b. Natural sampling



Quantization

- Sampling results in a series of pulses of varying amplitude values ranging between two limits: a min and a max.
- The amplitude values are infinite between the two limits.
- We need to map the *infinite* amplitude values onto a finite set of known values.
- This is achieved by dividing the distance between min and max into L zones, each of height Δ.

$$\Delta = (max - min)/L$$



Quantization codes
Normalized amplitude
7
6
5
4
3
2
4D
3D
2D
D
0
-D
19.7
16.2
11.0
7.5
-6.1
-5.5
-6.0
-9.4
Time

PCM Decoder

- To recover an analog signal from a digitized signal we follow the following steps:
  - We use a hold circuit that holds the amplitude value of a pulse till the next pulse arrives.
  - We pass this signal through a low pass filter with a cutoff frequency that is equal to the highest frequency in the pre-sampled signal.
- The higher the value of L, the less distorted a signal is recovered.

Components of a PCM decoder