Q1	**What is digital communication?explain types of signals?**

A)what is digital communication

Digital communication is a process of transferring data electronically from one place to another.

Data can be transferred by using different medium. The basic components of data communications are as follows:

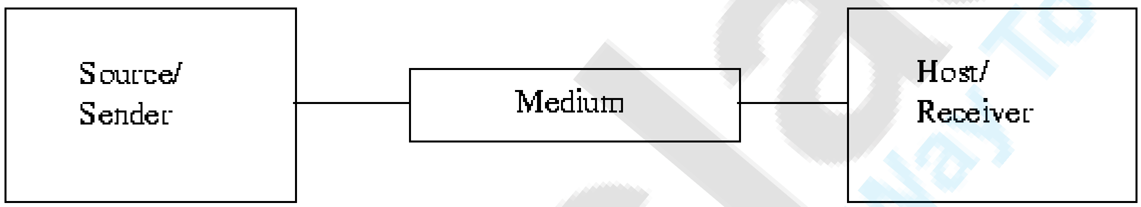
Message

Sender

Receiver

Medium/ communication channel

Encoder and decoder



B)what is signals

Signal is an electromagnetic or light wave that represents data. Signals are used to transfer data from one device to another through a communication medium.

Different forms of communication signals are as follows:

Digital signals

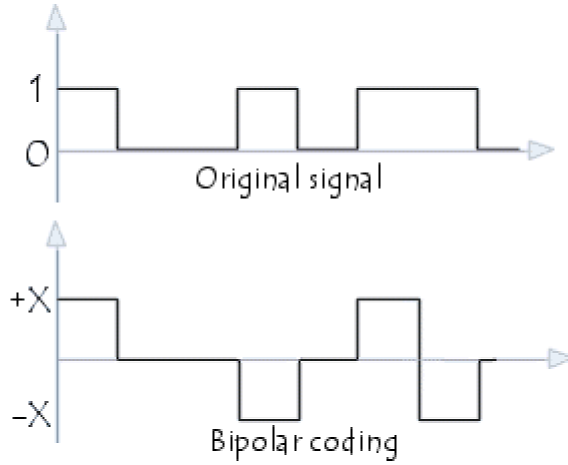
Analog signals

Digital Signals

Digital signal is a sequence of voltage represented in binary form. The digital signals are in the form of electrical pulses of ON and OFF. These signals are in discrete form.

Digital signals are faster and efficient. They provide low error rates. They also provide high transmission speed and high-quality voice transmission.

All data communication between the computers is in digital form. Computers understand and work only in digital form. The following figure represents a high voltage as a 1 and a low voltage as a 0.



Data Communications

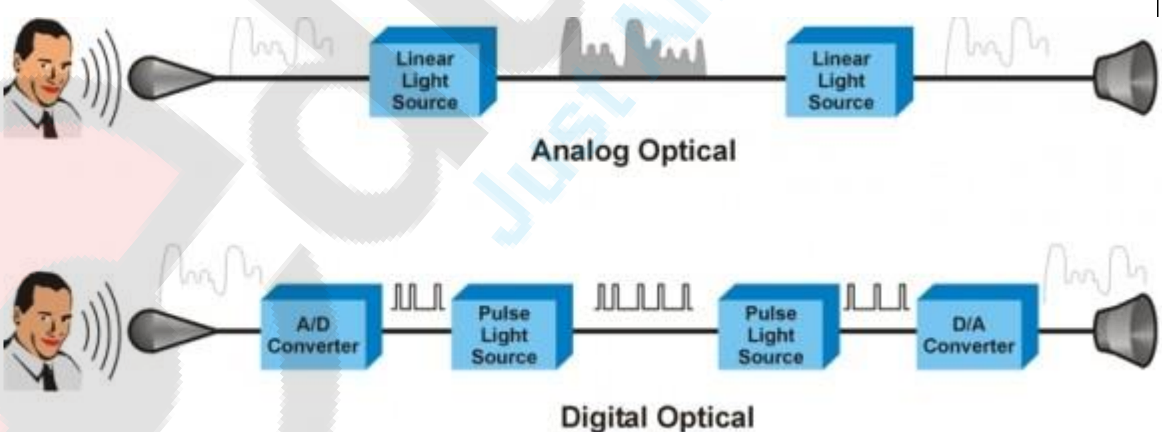
Analog Signals
Analog signal is a continuous electrical signal in the form of wave. The wave is known as carrier wave. Telephone line is most commonly used media for analog signals.

Characteristics of Analog Signals

Two characteristics of an analog wave are as follows:

Frequency: the number of times a wave repeats during a specific time interval is known as frequency.

Amplitude: the height of wave within a given period of time is known as amplitude.



Q2	Short note on switching and forwarding?

A communication system may include number of switches and nodes.At broad level, switching can be divided into two major categories:

- **Connectionless:** The data is forwarded on behalf of forwarding tables. No previous handshaking is required and acknowledgements are optional.
- **Connection Oriented:** Before switching data to be forwarded to destination, there is a need to pre-establish circuit along the path between both endpoints. Data is then forwarded on that circuit. After the transfer is completed, circuits can be kept for future use or can be turned down immediately.

Type of switching

1.Circuit Switching

When two nodes communicate with each other over a dedicated communication path, it is called circuit switching.There 'is a need of pre-specified route from which data will travels and no other data is permitted.In circuit switching, to transfer the data, circuit must be established so that the data transfer can take place.

Circuits can be permanent or temporary. Applications which use circuit switching may have to go through three phases:

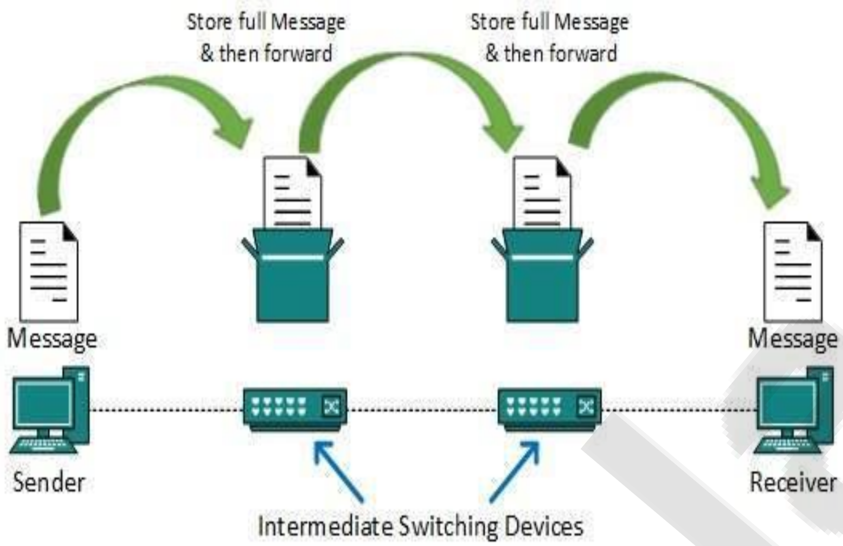
- Establish a circuit
- Transfer the data
- Disconnect the circuit

Circuit switching was designed for voice applications. Telephone is the best suitable example of circuit switching. Before a user can make a call, a virtual path between caller and callee is established over the network.

2.Message Switching

This technique was somewhere in middle of circuit switching and packet switching. In message switching, the whole message is treated as a data unit and is switching / transferred in its entirety.

A switch working on message switching, first receives the whole message and buffers it until there are resources available to transfer it to the next hop. If the next hop is not having enough resource to accommodate large size message, the message is stored and switch waits.



This technique was considered substitute to circuit switching. As in circuit switching the whole path is blocked for two entities only. Message switching is replaced by packet switching. Message switching has the following drawbacks:

- Every switch in transit path needs enough storage to accommodate entire message.
- Because of store-and-forward technique and waits included until resources are available, message switching is very slow.
- Message switching was not a solution for streaming media and real-time applications.

3.Packet Switching

Shortcomings of message switching gave birth to an idea of packet switching. The entire message is broken down into smaller chunks called packets. The switching information is added in the header of each packet and transmitted independently.

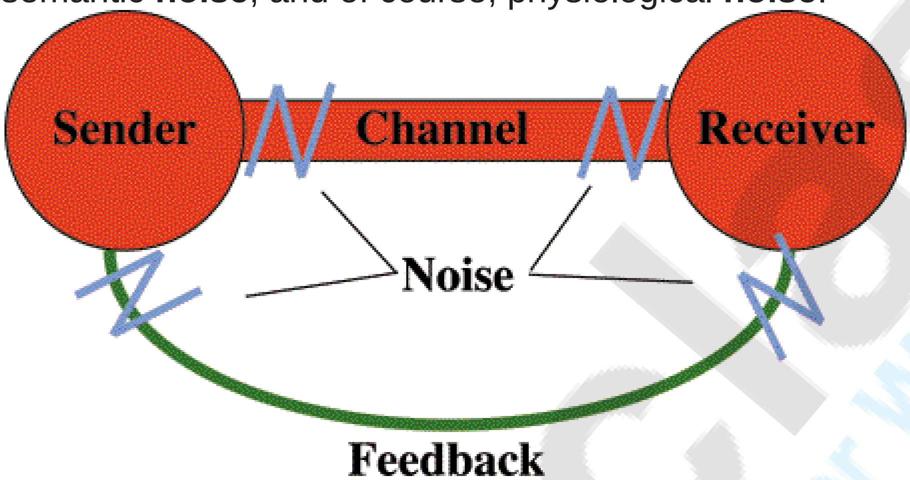
It is easier for intermediate networking devices to store small size packets and they do not take much resources either on carrier path or in the internal memory of switches.

Packet switching enhances line efficiency as packets from multiple applications can be multiplexed over the carrier. The internet uses packet switching technique. Packet switching enables the user to differentiate data streams based on priorities. Packets are stored and forwarded according to their priority to provide quality of service.

Q3	**Explian Noise**

Answer:

Noise is any type of disruption that interferes with the transmission or interpretation of information from the sender to the receiver. There are different types of **noise**, such as physical **noise**, psychological **noise**, semantic **noise**, and of course, physiological **noise**.



TYPE OF NOISE

Thermal noise

Thermal noise is approximately white, meaning that its power spectral density is nearly equal throughout the frequency spectrum. The amplitude of the signal has very nearly a Gaussian probability density function. A communication system affected by thermal noise is often modeled as an additive white Gaussian noise (AWGN) channel.

he root mean square (RMS) voltage due to thermal noise generated in a resistance *R* (ohms) over bandwidth Δ*f* (hertz), is given by

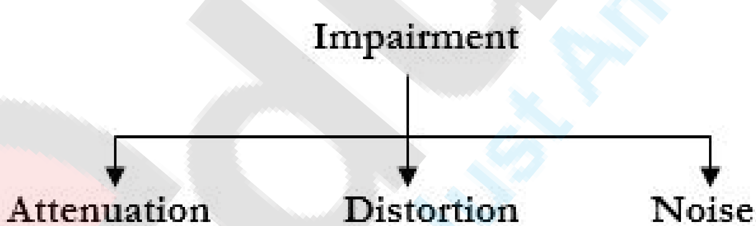
$$vn=\sqrt{4KbTR\Delta f}$$

where k_B is Boltzmann's constant (joules per kelvin) and *T* is the resistor's absolute temperature (kelvin).

As the amount of thermal noise generated depends upon the temperature of the circuit, very sensitive circuits such as preamplifiers in radio telescopes are sometimes cooled in liquid nitrogen to reduce the noise level.

Shot noise

If electrons flow across a barrier, then they have discrete arrival times. Those discrete arrivals exhibit shot noise. The output of a shot noise generator is easily set by the current. Typically, the barrier in a diode is used.[3]

	Shot noise in electronic devices results from unavoidable random statistical fluctuations of the electric current when the charge carriers (such as electrons) traverse a gap. The current is a flow of discrete charges, and the fluctuation in the arrivals of those charges creates shot noise. Shot noise is similar to the noise created by rain falling on a tin roof. The flow of rain may be relatively constant, but the raindrops arrive discretely. **Flicker noise** Flicker noise, also known as 1/*f* noise, is a signal or process with a frequency spectrum that falls off steadily into the higher frequencies, with a pink spectrum. It occurs in almost all electronic devices, and results from a variety of effects, though always related to a direct current. **Burst noise** Burst noise consists of sudden step-like transitions between two or more levels (non-Gaussian), as high as several hundred microvolts, at random and unpredictable times. Each shift in offset voltage or current lasts for several milliseconds, and the intervals between pulses tend to be in the audio range (less than 100 Hz), leading to the term *popcorn noise* for the popping or crackling sounds it produces in audio circuits.
Q.4	Explain Transmission Impairments.
Ans:	Transmission Impairments.:  In any communication system, the received signal is never is identical to the transmitted one due to some transmission impairments. The quality of analog signals will deteriorate due to transmission impairments as given above. Attenuation: The strength of a signal decrease with the increase in distance travelled over a medium. Attenuation means loss of energy. When any signal travels over a medium or channel, it loses some of its energy in the form of heat in the resistance of the medium. Attenuation decides the signal to noise ratio hence the quality of received signal.

Attenuation is given in decibels as:

Attenuation (dB) = 10log10 (Pout/Pin)

Where, Pin= Power at the sending end

Pout= Power at the receiving end

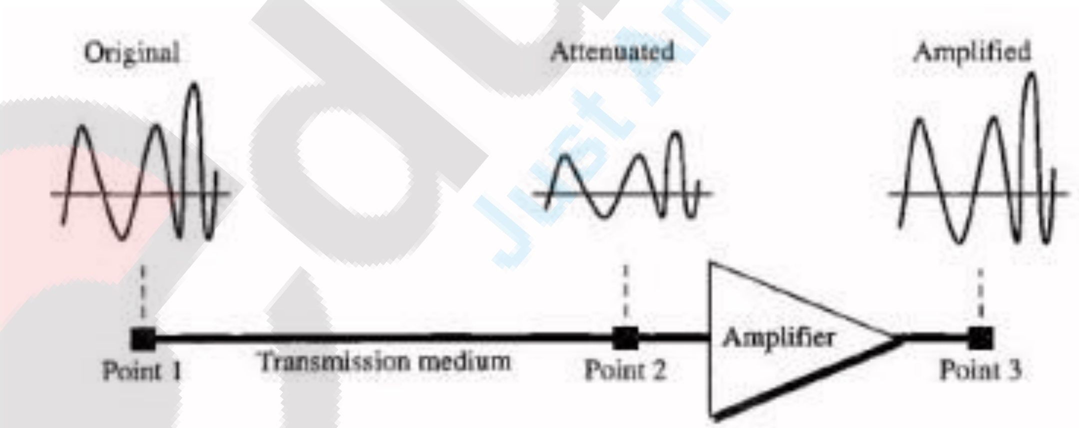
Distortion (Harmonic):

Another meaning of distortion is change in shape of the signal. This type of distortion is observed for the composite signals made by different frequencies. If the medium is not perfect, then all the frequency components present at the input will not only be equally attenuated and will not be proportionally delayed.

Noise:

When the data travels over a transmission medium, noise gets added to it. Noise is a major limiting factor in communication system performance. Noise can be categorized into four types as follows:

(i) Thermal noise (ii) Intermodulation noise (iii) Crosstalk (iv) Impulse noise



Q5.	Define Data rate limits-Nyquist‟s theorem (Nyquist Theorem)

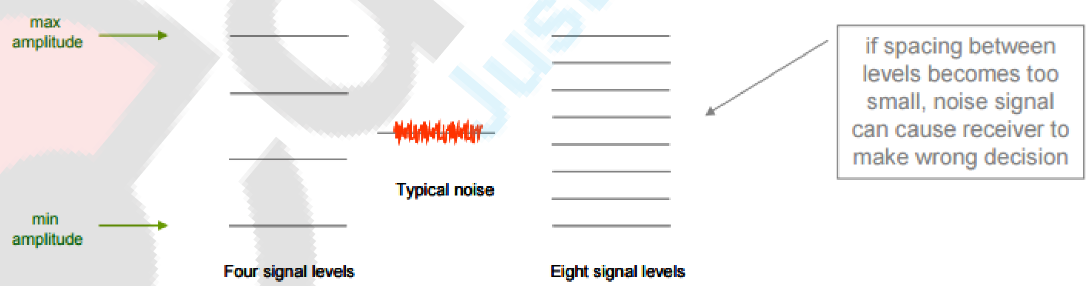
The Nyquist Theorem, also known as the sampling theorem, is a principle that engineers follow in the digitization of analog signals. For analog-to-digital conversion (ADC) to result in a faithful reproduction of the signal, slices, called samples, of the analog waveform must be taken frequently. The number of samples per second is called the sampling rate or sampling frequency.

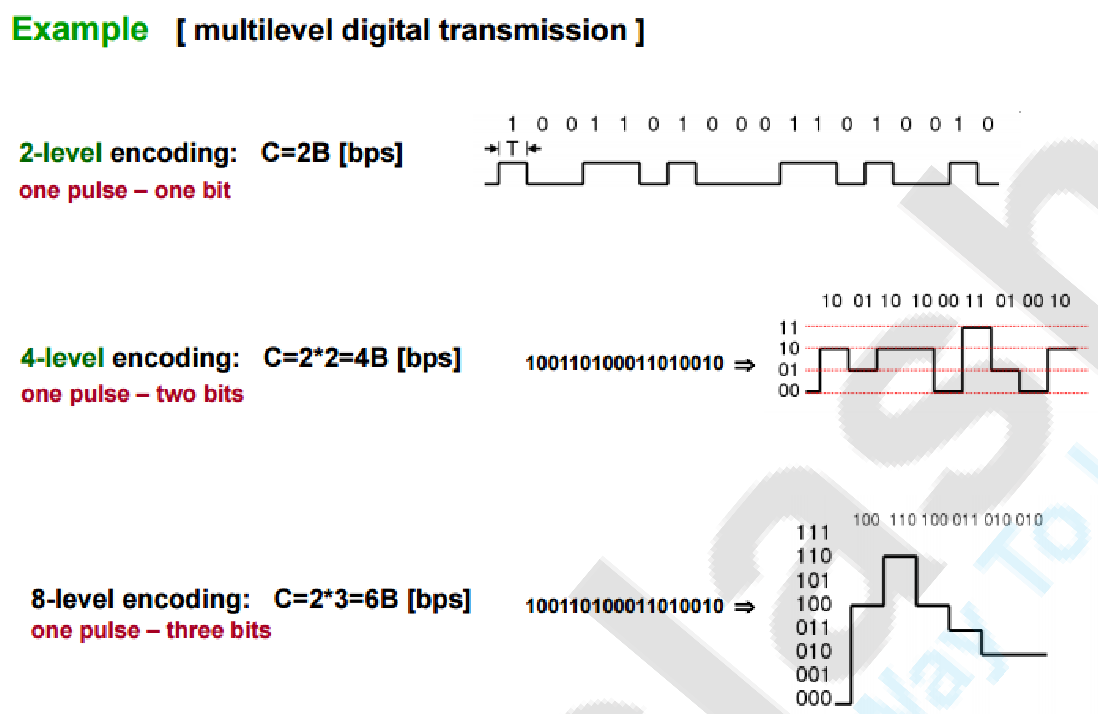
Any analog signal consists of components at various frequencies. The simplest case is the sine wave, in which all the signal energy is concentrated at one frequency. In practice, analog signals usually have complex waveforms, with components at many frequencies. The highest frequency component in an analog signal determines the bandwidth of that signal. The higher the frequency, the greater the bandwidth, if all other factors are held constant

Nyquist Law – **max rate at which digital data can be transmitted over a communication channel of bandwidth B [Hz] is**

$$C_{noiseless} = 2 \cdot B \cdot \log_2 M \ \text{[bps]}$$

- **M – number of discrete levels in digital signal**
- **$M \uparrow \Rightarrow C \uparrow$, however this places increased burden on receiver – instead of distinguishing one of two possible signals, now it must distinguish between M possible signals**
  - **especially complex in the presence of noise**



	
Q.6	Define Shannon's theorem.
	The Shannon-Hartley theorem indicates that with sufficiently advanced coding techniques, transmission that nears the maximum channel capacity – is possible with arbitrarily small errors. One can intuitively reason that, for a given communication system, as the information rate increases, the number of errors per second will also increase. Shannon's information theory tells us the amount of information a channel can carry. In other words it specifies the capacity of the channel. The theorem can be stated in simple terms as follows A given communication system has a maximum rate of information C known as the channel capacity If the transmission information rate R is less than C, then the data transmission in the presence of noise can be made to happen with arbitrarily small error probabilities by using intelligent coding techniques To get lower error probabilities, the encoder has to work on longer blocks of signal data. This entails longer delays and higher computational requirements

Shannon Law – maximum transmission rate over a channel with bandwidth B, with Gaussian distributed noise, and with signal-to-noise ratio SNR=S/N, is

$$C_{noisy} = B \cdot \log_2(1 + SNR) \ \ [bps]$$

- theoretical limit – there are numerous impairments in every real channel besides those taken into account in Shannon's Law (e.g. attenuation, delay distortion, or impulse noise)
- no indication of levels – no matter how many levels we use, we cannot achieve a data rate higher than the capacity of the channel
- in practice we need to use both methods (Nyquist & Shannon) to find what data rate and signal levels are appropriate for each particular channel:

The Shannon capacity gives us the upper limit!
The Nyquist formula tells us how many levels we need!

Example [data rate over telephone line]

What is the theoretical highest bit rate of a regular telephone line?
A telephone line normally has a bandwidth of 3000 Hz (300 Hz to 3300 Hz). The signal-to-noise ratio is usually 35 dB (3162) on up-link channel (user-to-network).

Solution:

We can calculate the theoretical highest bit rate of a regular telephone line as

$$C = B \log_2(1 + SNR) =$$
$$= 3000 \log_2(1 + 3162) =$$
$$= 3000 \log_2(3163)$$

$$C = 3000 \times 11.62 = 34{,}860 \text{ bps}$$