Rupa EECE Dr Vanaja Patloll

Rs 12

Rupa Mam (EECE) 4u

UNIT- III

PRINCIPLES OF COMMUNICATION ENGINEERING

3.1. Block Diagram of Communication System with Detailed Explanation:

Communication is the process of establishing connection or link between two points for information exchange.

(OR)

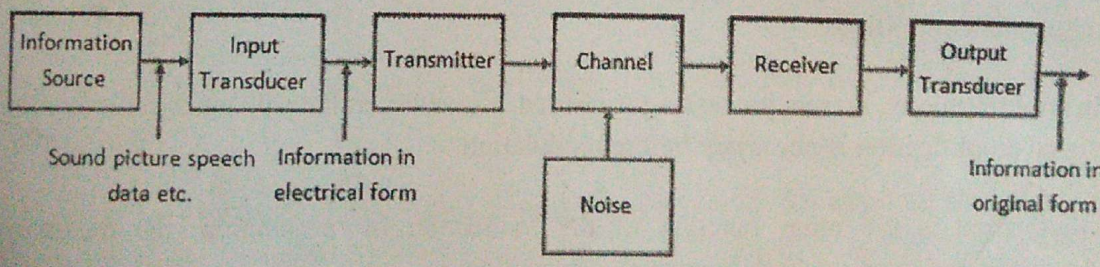
Communication is simply the basic process of exchanging information.

The electronics equipments which are used for communication purpose are called communication equipments. Different communication equipments when assembled together form a **communication system**.

Typical example of communication system are line telephony and line telegraphy, radio telephony and radio telegraphy, radio broadcasting, point-to-point communication and mobile communication, computer communication, radar communication, television broadcasting, radio telemetry, radio aids to navigation, radio aids to aircraft landing etc.

Block Diagram of Communication System

Fig.1 shows the block diagram of a general communication system, in which the different functional elements are represented by blocks.



The essential components of a communication system are information source, input transducer, transmitter, communication channel, receiver and destination.

Shivaji Patil

(i) Information Source

As we know, a communication system serves to communicate a message or information. This information originates in the information source.

In general, there can be various messages in the form of words, group of words, code, symbols, sound signal etc. However, out of these messages, only the desired message is selected and communicated.

Therefore, we can say that the function of information source is to produce required message which has to be transmitted.

(ii) Input Transducer

A transducer is a device which converts one form of energy into another form.

The message from the information source may or may not be electrical in nature. In a case when the message produced by the information source is not electrical in nature, an input transducer is used to convert it into a time-varying electrical signal.

For example, in case of radio-broadcasting, a microphone converts the information or massage which is in the form of sound waves into corresponding electrical signal.

(iii) Transmitter

The function of the transmitter is to process the electrical signal from different aspects.

For example in radio broadcasting the electrical signal obtained from sound signal, is processed to restrict its range of audio frequencies (upto 5 kHz in amplitude modulation radio broadcast) and is often amplified.

In wire telephony, no real processing is needed. However, in long-distance radio communication, signal amplification is necessary before modulation.

Modulation is the main function of the transmitter. In modulation, the message signal is superimposed upon the high-frequency carrier signal.

In short, we can say that inside the transmitter, signal processings such as restriction of range of audio frequencies, amplification and modulation of are achieved.

All these signal processing stages of the message signal are done just to ease the transmission of the signal through the channel.

(iv) Channel and Noise

The term channel means the medium through which the message travels from the transmitter to the receiver. In other words, we can say that the function of the channel is to provide a physical connection between the transmitter and the receiver.

There are two types of channels, namely point-to-point channels and broadcast channels.

Examples of point-to-point channels are wire lines, microwave links and optical fibres. Wire-lines operate by guided electromagnetic waves and they are used for local telephone transmission.

In case of microwave links, the transmitted signal is radiated as an electromagnetic wave in free space. Microwave links are used in long distance telephone transmission.

An optical fiber is a low-loss, well-controlled, guided optical medium. Optical fibres are used in optical communications.

Although these three channels operate differently, they all provide a physical medium for the transmission of signals from one point to another point. Therefore, for these channels, the term point-to-point is used.

On the other hand, the broadcast channel provides a capability where several receiving stations can be reached simultaneously from a single transmitter.

An example of a broadcast channel is a satellite in geostationary orbit, which covers about one third of the earth's surface.

During the process of transmission and reception the signal gets distorted due to noise introduced in the system.

Noise is an unwanted signal which tends to interfere with the required signal. Noise signal is always random in character. Noise may interfere with signal at any point in a communication system. However, the noise has its greatest effect on the signal in the channel.

Sri Durga Pattala

(i) Information Source

As we know, a communication system serves to communicate a message or information. This information originates in the information source.

In general, there can be various messages in the form of words, group of words, code, symbols, sound signal etc. However, out of these messages, only the desired message is selected and communicated.

Therefore, we can say that the function of information source is to produce required message which has to be transmitted.

(ii) Input Transducer

A transducer is a device which converts one form of energy into another form.

The message from the information source may or may not be electrical in nature. In a case when the message produced by the information source is not electrical in nature, an input transducer is used to convert it into a time-varying electrical signal.

For example, in case of radio-broadcasting, a microphone converts the information or massage which is in the form of sound waves into corresponding electrical signal.

(iii) Transmitter

The function of the transmitter is to process the electrical signal from different aspects.

For example in radio broadcasting the electrical signal obtained from sound signal, is processed to restrict its range of audio frequencies (upto 5 kHz in amplitude modulation radio broadcast) and is often amplified.

In wire telephony, no real processing is needed. However, in long-distance radio communication, signal amplification is necessary before modulation.

Modulation is the main function of the transmitter. In modulation, the message signal is superimposed upon the high-frequency carrier signal.

In short, we can say that inside the transmitter, signal processings such as restriction of range of audio frequencies, amplification and modulation of are achieved.

All these signal processing stages of the message signal are done just to ease the transmission of the signal through the channel.

(iv) Channel and Noise

The term channel means the medium through which the message travels from the transmitter to the receiver. In other words, we can say that the function of the channel is to provide a physical connection between the transmitter and the receiver.

There are two types of channels, namely point-to-point channels and broadcast channels.

Examples of point-to-point channels are wire lines, microwave links and optical fibres. Wire-lines operate by guided electromagnetic waves and they are used for local telephone transmission.

In case of microwave links, the transmitted signal is radiated as an electromagnetic wave in free space. Microwave links are used in long distance telephone transmission.

An optical fiber is a low-loss, well-controlled, guided optical medium. Optical fibres are used in optical communications.

Although these three channels operate differently, they all provide a physical medium for the transmission of signals from one point to another point. Therefore, for these channels, the term point-to-point is used.

On the other hand, the broadcast channel provides a capability where several receiving stations can be reached simultaneously from a single transmitter.

An example of a broadcast channel is a satellite in geostationary orbit, which covers about one third of the earth's surface.

During the process of transmission and reception the signal gets distorted due to noise introduced in the system.

Noise is an unwanted signal which tends to interfere with the required signal. Noise signal is always random in character. Noise may interfere with signal at any point in a communication system. However, the noise has its greatest effect on the signal in the channel.

(v) Receiver

The main function of the receiver is to reproduce the message signal in electrical form from the distorted received signal. This reproduction of the original signal is accomplished by a process known as the demodulation or detection. Demodulation is the reverse process of modulation carried out in transmitter.

(vi) Destination

Destination is the final stage which is used to convert an electrical message signal into its original form.

For example in radio broadcasting, the destination is a loudspeaker which works as a transducer i.e. converts the electrical signal in the form of original sound signal.

3.2. Modulation:

A process of varying one of parameter of carrier signal in accordance with the amplitude of message signal.

The process by which some characteristics of a carrier wave is varied in accordance with an information-bearing signal. Modulation is an important step of communication system. Modulation is defined as the process whereby some characteristic (the amplitude, frequency or phase) of a high frequency carrier wave is varied in accordance with instantaneous value intensity of low frequency signal wave (modulating wave).

Need of modulation: –

i. **Modulation for ease of radiation (To reduce antenna height):** if the communication channel consists of free space, then antennas are needed to radiate and receive the signal. Efficient electromagnetic radiation requires antennas whose dimensions are of the same order of magnitude as the wavelength of the signal being radiated many signals, including audio signals, have frequency components down to 100 Hz or lower. For efficient transmission of these signals, antennas of about 300 km long will be necessary. If modulation is used to impress the message signal on a high frequency carrier, say at 100 MHz, then antennas needed would have dimensions of about a meter and become realizable.

ii. **Modulation for multiplexing:** If more than one signal utilizes a single channel, modulation may be used to translate different signals to different frequency bands, thus enabling the receiver to select the desired signal Applications of multiplexing include data telemetry, FM stereophonic broadcasting and long distance telephony,

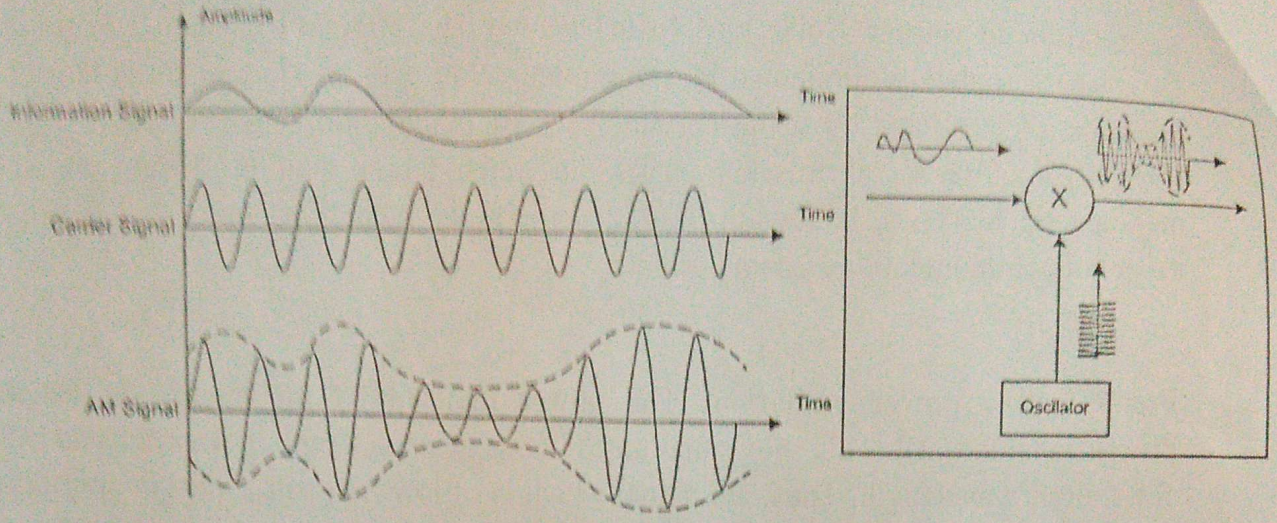
iii. **Modulation to reduce Noise and Interference:** The effect of noise and interference cannot be completely eliminated in a communication system. However it is possible to minimize their effects by using certain types of modulation schemes. These schemes generally require a transmission bandwidth much larger than the bandwidth of the message signal. Thus, bandwidth is traded for noise reduction, which is an important aspect of communication system design.

iv. **For effective power radiation:** The power radiated by an antenna of length l is proportional to $(l/\lambda)^2$. This shows that for the same antenna length, power radiated is large for shorter wavelength. Thus, our signal which is of low frequency must be translated to the high frequency spectrum of the electromagnetic wave. This is achieved by the process of modulation

Types of Modulation:

There are three basic types of modulation techniques.
(i) Amplitude modulation (ii) Frequency modulation (iii) Phase modulation

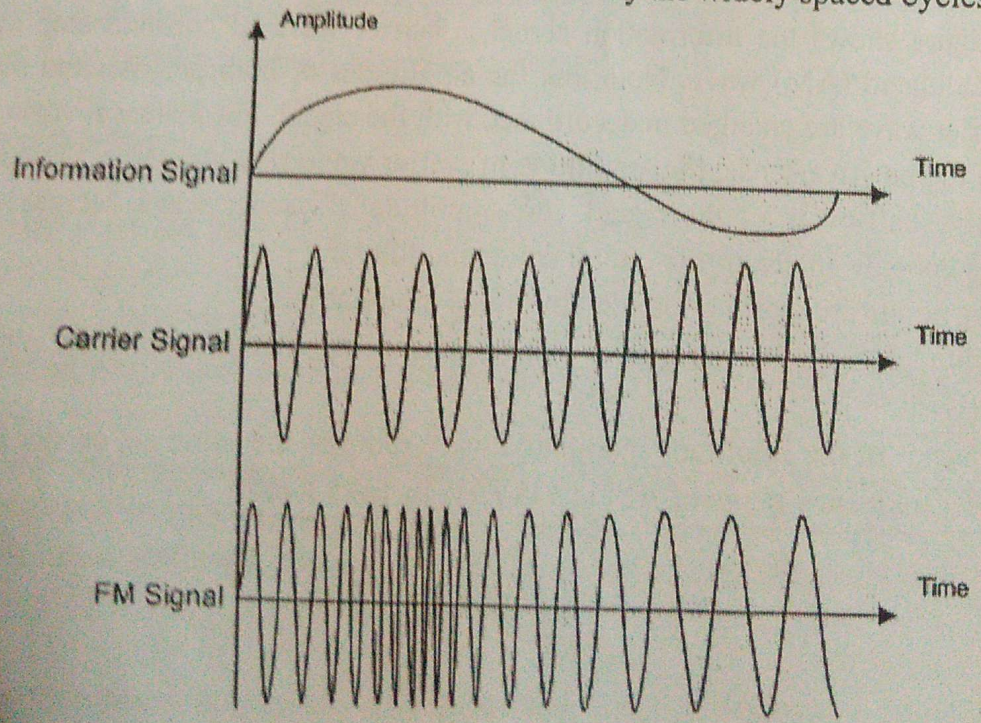
Amplitude Modulation:
When the amplitude of high frequency carrier wave is changed in accordance with the amplitude variations of the message signal, it is called amplitude modulation.
The below figure shows the information signal, a carrier wave of constant amplitude and the amplitude modulated (AM) wave. Note that the amplitudes of both positive and negative half-cycles of carrier wave are changed in accordance with the signal. For instance, when the signal is increasing in the positive sense, the amplitude of carrier wave also increases. On the other hand, during negative half-cycle of the signal, the amplitude of carrier wave decreases. Amplitude modulation is done by an electronic circuit called modulator.
The following points are worth noting in amplitude modulation:
(i) The amplitude of the carrier wave changes according to the amplitude variations of the information signal.
(iii) The frequency of the amplitude modulated wave remains the same i.e. carrier frequency fc.
(iv) The carrier frequency range of AM is 535 KHz to 1635 KHz.



Frequency Modulation:

It is the process of varying the frequency of the carrier wave in accordance with the amplitude variation of modulating signal.

The frequency variations of carrier wave depend upon the instantaneous amplitude of the signal as shown in below fig. When the signal voltage is zero, the carrier frequency is unchanged. When the signal approaches its positive peak, the carrier frequency is increased to maximum as shown by the closely spaced cycles. However, during the negative peaks of signal as at *D*, the carrier frequency is reduced to minimum as shown by the widely spaced cycles.



1. Frequency modulation is widely used for FM radio broadcasting. Commercial FM broadcast range is from 88 MHz to 108 MHz.
2. It is also used in telemetry, radar, seismic prospecting, and monitoring newborns for seizures via EEG, two-way radio systems, music synthesis, magnetic tape-recording systems and
3. Some video-transmission systems.

Advantages of FM over AM:

The following are the advantages of FM over AM:

1. It gives noiseless reception. As discussed before, noise is a form of amplitude variations and a FM receiver will reject such signals.FM is less prone to some kinds of interference, because almost all natural and man-made interference is seen as amplitude changes. Since the amplitude changes in AM contain the intelligence, any attempt to eliminate the noise adversely affects the received signal. However, in FM, the intelligence is not carried by amplitude changes but instead by frequency changes.
2. The operating frequency range is quite large.
3. The efficiency of transmission is very high.

Disadvantages of FM:

1. Much more Bandwidth is required (as much as 20 times than what is required in AM).
2. More complicated receiver and transmitter. AM is useful where a simple, low-cost receiver and detector is desired.

Comparison of FM and AM:

The comparison of FM and AM is given in the table below.

S.No	FM	AM
1	The process of varying the frequency of the carrier wave in accordance with the amplitude variations of the modulating signal.	The process of varying the amplitude of the carrier wave in accordance with the amplitude variations of the modulating signal.
2	The carrier frequency range is 88MHz to 108MHz.	The carrier frequency range is 535KHz to 1635KHz.
3	The circuit complexity is high.	The circuit complexity is low.
4	The noise immunity of FM is high.	AM is less immune to noise compared to FM.

5	Bandwidth requirement of FM is high. (As much as 20 times than what is required in AM).	Bandwidth requirement is less.
6	Important application : Radio broadcasting	Important application : Television broadcast

3.3. Introduction to wired and wireless communications:

Transmission media is a pathway that carries the information from sender to receiver. We use different types of cables or waves to transmit data. Data is transmitted normally through electrical or electromagnetic signals. Transmission media is also called as communication channel.

Types of Transmission Media:
Transmission media is broadly classified into two groups.
1. Wired or Guided Media or Bound Transmission Media
2. Wireless or Unguided Media or Unbound Transmission Media

Wired or Guided Media or Bounded Transmission Media: Bounded transmission media consists of the cables that have physical existence and are limited by the physical geography. Popular bounded transmission media in use are twisted pair cable, co-axial cable and fiber optical cable. Each of them has its own characteristics like transmission speed, effect of noise, physical appearance, cost etc.

Wireless or Unguided Media or Unbound Transmission Media: Unbounded transmission media are the ways of transmitting data without using any cables. These media are not bounded by physical geography. This type of transmission is called Wireless communication. Nowadays wireless communication is becoming popular. Wireless LANs are being installed in office and college campuses. This transmission uses Microwave, Radio wave, Infrared waves are some of popular unbound transmission media.

The data transmission capabilities of various Medias vary differently depending upon the various factors. These factors are:

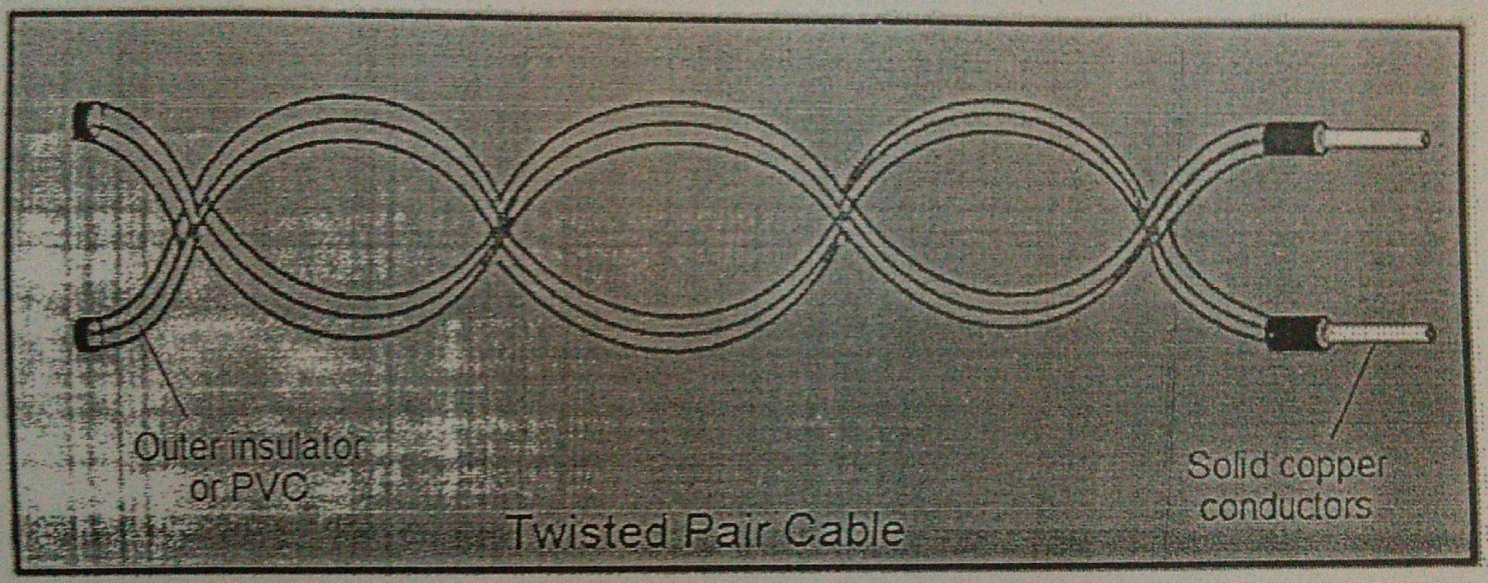
3.3.1. Wired communication:

It refers to the transmission of data over a wire-based . Examples include telephone networks, cable television or internet access, and fiber-optic communication.

- Large installed base.
- Reasonable cost.
- Relatively low bandwidth
- Susceptible to external interference.
- Shielding can reduce external interference.

Twisted pair:

The pair of twisted wires is the simplest transmission medium.



Advantages of Twisted pair cable:

1. It can be used to carry both analog and digital data.
2. It is relatively easy to implement and terminate.
3. It is the least expensive media of transmission for short distances.
4. If portion of a twisted pair cable is damaged it does not effect the entire network.

Disadvantages of Twisted pair cable:

1. It offers poor noise immunity as a result signal distortion.
2. Attenuation is very high.
3. It supports lower bandwidth as compared to other Medias.
4. It offers very poor security and is relatively easy to tap.
5. Being thin in size, they are likely to break easily.

Applications of Twisted Pair Cables:

Some of the applications of twisted pair cables are as follows:

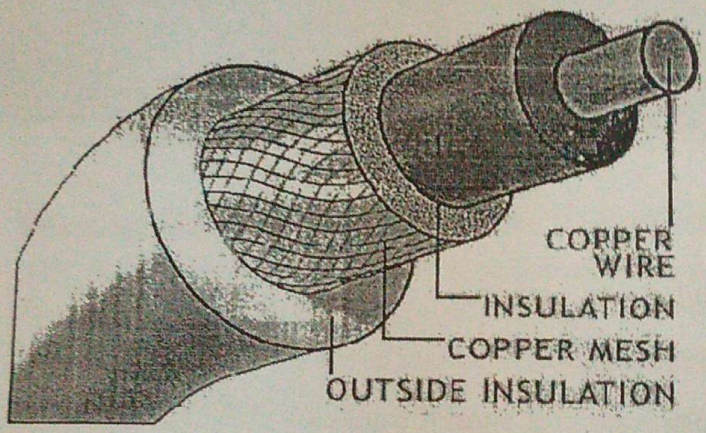
(1) In telephone lines to carry voice and data channels.

(2) Local area networks.

Wired Transmission Media - Coaxial Cable:

Coaxial cables are the guided media that carries the signal of higher frequency range compared to twisted pair cable. Due to the shield provided, this cable has excellent noise immunity.

A coaxial cable consists of many small cables in a protective cover. The cover shields the cable from physical dangers as well as from electromagnetic interference. Within the cover, the various cables are shielded from interference with one another. Coaxial cables are used in communication networks that require many simultaneous communication links.



Coaxial cable is a **two-conductor cable** in which one conductor forms an electromagnetic shield around the other. The two conductors are separated by **insulation**.

Features:

It provides better noise immunity than twisted pair.

This cable is able to transmit data at higher rates.

Limitations:

High installation cost

High maintenance cost.

Advantages of Coaxial Cables:

1. It can be used for both analog and digital transmission.
2. It offers higher bandwidth as compared to twisted pair cable and can span longer distances.
3. Because of better shielding in coaxial cable, loss of signal or attenuation is less.
4. Better shielding also offers good noise immunity.
5. It is relatively inexpensive as compared to optical fibers.
6. It is not as easy to tap as twisted pair because copper wire is contained in plastic jacket.

Disadvantages of Coaxial Cables:

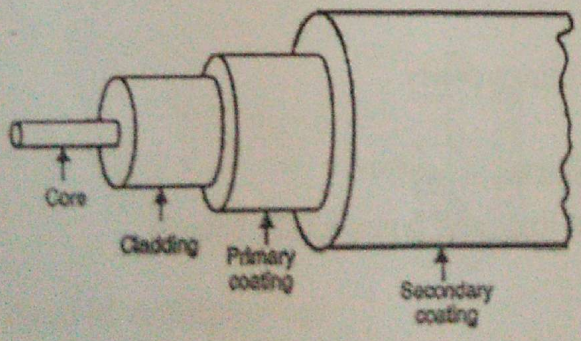
1. It is usually more expensive than twisted pair.

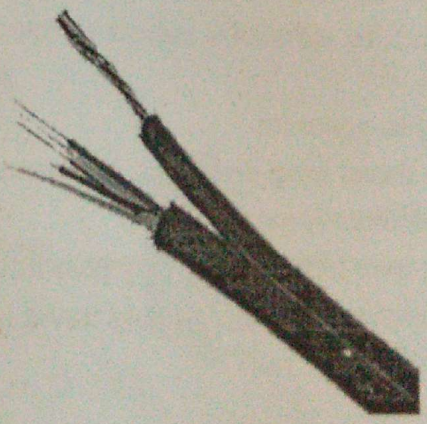
Applications of Co-axial Cables:

(1) telephone networks.
(2) Cable TV
(3) Traditional Ethernet LANs

Fiber Optic: An optical fiber cable is a cable containing one or more optical fibers that are used to carry light. The optical fiber elements are typically individually coated with plastic layers and contained in a protective tube suitable for the environment where the cable will be deployed

- Fiber optic cables have a much greater bandwidth than metal cables. This means that they can carry more data.
- smaller size and lighter weight
- Fiber optic cables are less susceptible than metal cables to interference.
- Fiber optic cables are much thinner and lighter than metal wires.





Disadvantages:

- The main disadvantage of fiber optics is that the cables are expensive to install. In addition they require highly skilled installers
- expensive over short distance

Applications:

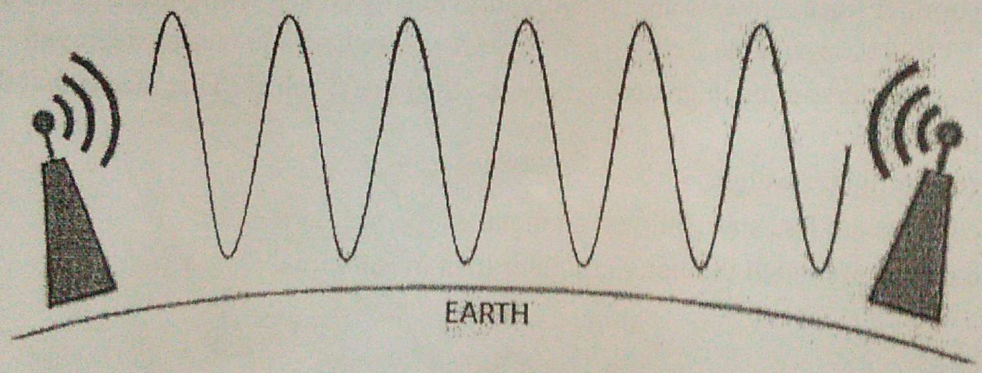
In TV and stereo systems, an optical cable can be used to transmit sound from a DVD player/TV to a sound system, such as a stereo receiver or sound bar. The optical cable can transmits high quality of sound, ensuring little or no sound degradation.

3.3.2. Wireless transmission:

It is a form of unguided media. Wireless communication involves no physical link established between two or more devices. Wireless signals are spread over in the air and are received and interpreted by appropriate antennas.

Radio Transmission:

Radio frequency is easier to generate and because of its large wavelength it can penetrate through walls and structures alike. Radio waves have frequency ranging from 3 KHz (Extremely Low Frequency) to 300 GHz (Extremely High Frequency). Radio waves at lower frequencies can travel through walls whereas higher RF can travel in straight line and bounce back. The power of low frequency waves decreases sharply as they cover long distance. High frequency radio waves have more power.



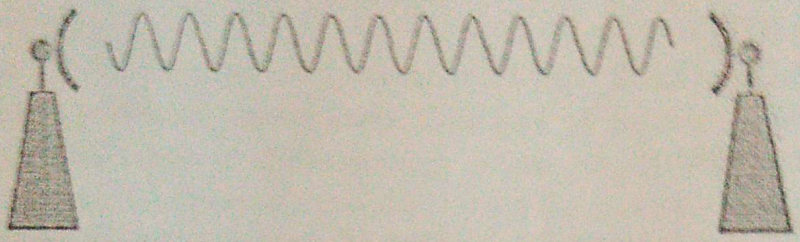
Features:

- Easy to generate
- Can travel long distances, and penetrate buildings easily
- Omnidirectional
- At lower frequencies, they pass through obstacles as well
- At higher frequencies, they travel in straight lines and bounce off obstacle
- Absorbed by rain

Microwave Transmission:

Electromagnetic waves above 100 MHz tend to travel in a straight line and signals over them can be sent by beaming those waves towards one particular station. Because Microwaves travels in straight lines, both sender and receiver must be aligned to be strictly in line-of-sight.

Microwaves have the frequency ranging from 300 MHz to 300 GHz.



Microwave transmission depends highly upon the weather conditions and the frequency it is using.

Infrared Transmission:

Infrared wave lies in between visible light spectrum and microwaves. It has frequency ranging from 300-GHz to 430THz.

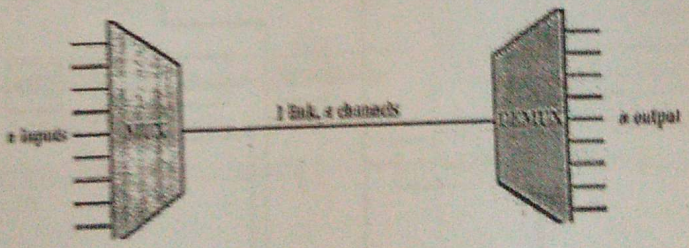
Infrared wave is used for very short range communication purposes such as television's remote. Infrared travels in a straight line hence it is directional by nature. Because of high frequency range, Infrared cannot cross wall-like obstacles.

Application

- For short-range communication like Remote controls for TVs, VCRs and stereos.

3.4. Multiplexing:

Multiplexing means "sharing a medium". It is a form of data transmission in which one communication channel carries several transmissions at the same time. In simple words, the method of dividing a single channel into many channels so that a number of independent signals may be transmitted on it is known as Multiplexing.



Need of multiplexing:

Multiplexing can be used to achieve following:

- To send a large number of signals simultaneously
- To reduce the cost of transmission
- To make effective use of the available bandwidth

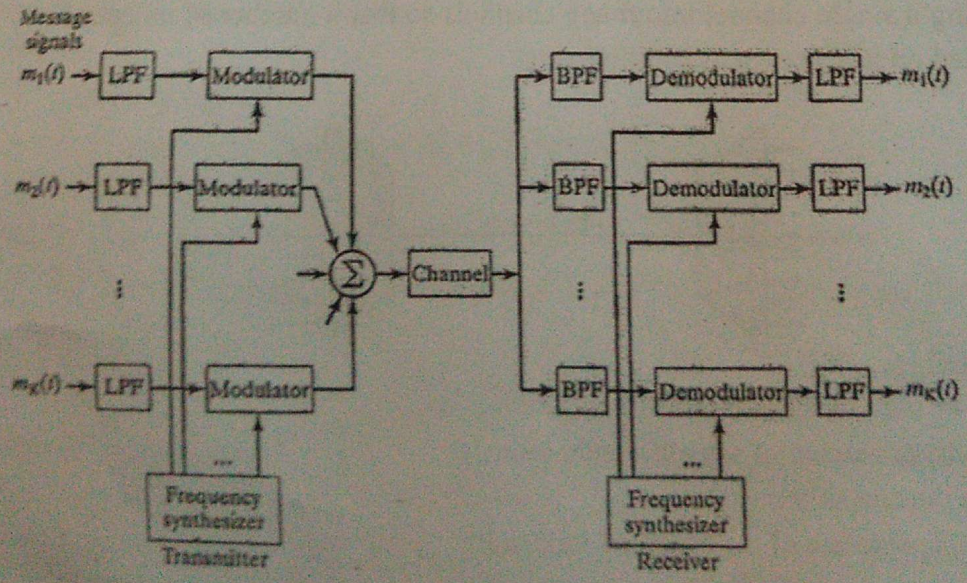
Multiplexing techniques can be divided into two basic categories:
Frequency Division Multiplexing (FDM)
Time Division Multiplexing (TDM)

Frequency Division Multiplexing (FDM):

In FDM the available bandwidth is divided into a number of smaller independent logical channels with each channel having a small bandwidth. It assigns "frequency ranges" to each "user" or "signal" on a medium. Thus, all signals are transmitted at the same time, each using different frequencies. The method of using a number of carrier frequencies, each of which is modulated by an independent signal is in fact frequency division multiplexing.

It is most popular and is used extensively in radio and TV transmission. Here the frequency spectrum is divided into several logical channels, giving each user exclusive possession of a particular frequency band.

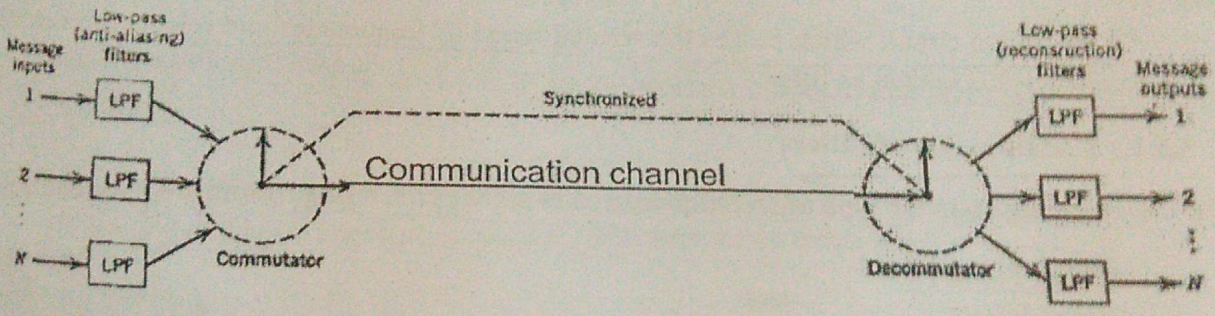
In frequency division multiplexing, the available bandwidth of a single physical medium is subdivided into several independent frequency channels. Independent message signals are translated into different frequency bands using modulation techniques, which are combined by a linear summing circuit in the multiplexer, to a composite signal. The resulting signal is then transmitted along the single channel by electromagnetic means. Basic approach is to divide the available bandwidth of a single physical medium into a number of smaller, independent frequency channels. Using modulation, independent message signals are translated into different frequency bands. All the modulated signals are combined in a linear summing circuit to form a composite signal for transmission. The carriers used to modulate the individual message signals are called *sub-carriers*, shown as f1, f2, …, fn. At the receiver, the modulated signals are separated by the band pass filters and then demodulated for getting the original message signals.



Frequency-division multiplexing of multiple signals.

Time Division Multiplexing (TDM):

In TDM, sharing is accomplished by dividing available "transmission time" on a medium/channel among users. Each user of the channel is allotted a small time interval during which one sample of the message is transmitted. In TDM, users send message sequentially one after another. Each user can use the full channel bandwidth during the period he has control over the channel.



In frequency division multiplexing, all signals are transmitted at the same time with different frequencies, but in Time-division multiplexing all signals are transmitted with the same bandwidth at different times. In TDM, an electronic commutator (rotary switch) sequentially samples all message signals and combines them to form a composite signal, which travels through the media and is being demultiplexed into appropriate independent message signals by the corresponding decommutator at the receiving end. Synchronization should be provided between commutator and decommutator for perfect reproduction of message signals.

Comparison between TDM and FDM:

S.No	FDM	TDM
1	The process of varying the frequency of the carrier wave in accordance with the amplitude variations of the modulating signal.	The process of varying the amplitude of the carrier wave in accordance with the amplitude variations of the modulating signal.
2	The carrier frequency range is 88MHz to 108MHz.	The carrier frequency range is 535KHz to 1635KHz.
3	The circuit complexity is high.	The circuit complexity is low.
4	The noise immunity of FM is high.	AM is less immune to noise compared to FM.

5	Bandwidth requirement of FM is high. (As much as 20 times than what is required in AM).	Bandwidth requirement is less.
6	Important application : Radio broadcasting	Important application : Television broadcasti

3.5. Filters:

An electronic circuit which passes the wanted range of frequencies and rejects the remaining frequencies is known as filter.

3.5.1. Classification of Filters

- Depending upon the type of techniques used in signal processing, filters are classified as:

i. Analog Filters, and
ii. Digital Filters.

Analog filters are designed to process analog signals using analog techniques, while digital filters process analog signals using digital techniques.

- Depending on the type of elements used in their construction, filters are classified as:

i. Active Filters, and
ii. Passive Filters.

A passive filter is built with passive components such as resistors, capacitors and inductors. Active filters, on the other hand, make use of transistors or op-amps in addition to resistors and capacitors.

- Depending upon the range of frequencies allowed by the filter, they are classified as:

i. Low Pass Filters,
ii. High Pass Filters,
iii. Bans Pass Filters, and
iv. Band Stop Filters.

1. **Low-Pass Filter** It is a circuit that has a constant output (or gain) from zero to a cut-frequency, f_c and attenuation of all frequencies above f_c.

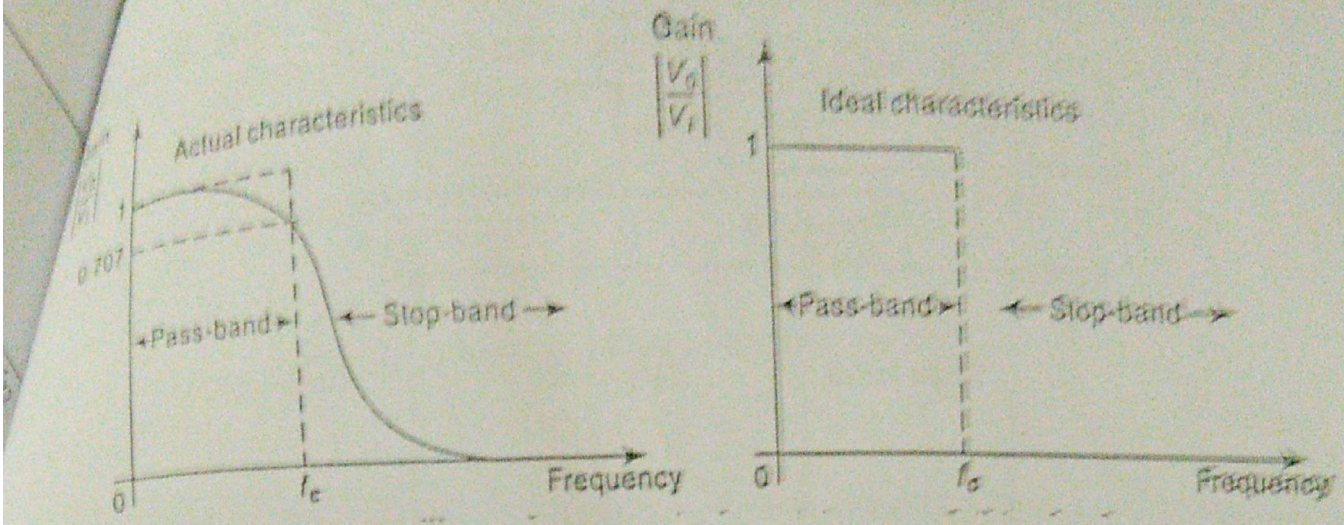


Fig: Low-pass filter characteristics: (a) Actual (b) Ideal

2. **High-Pass Filter** It is a circuit that attenuates all signals of frequency below the cut-off frequency and has a constant output (or gain) above this frequency.

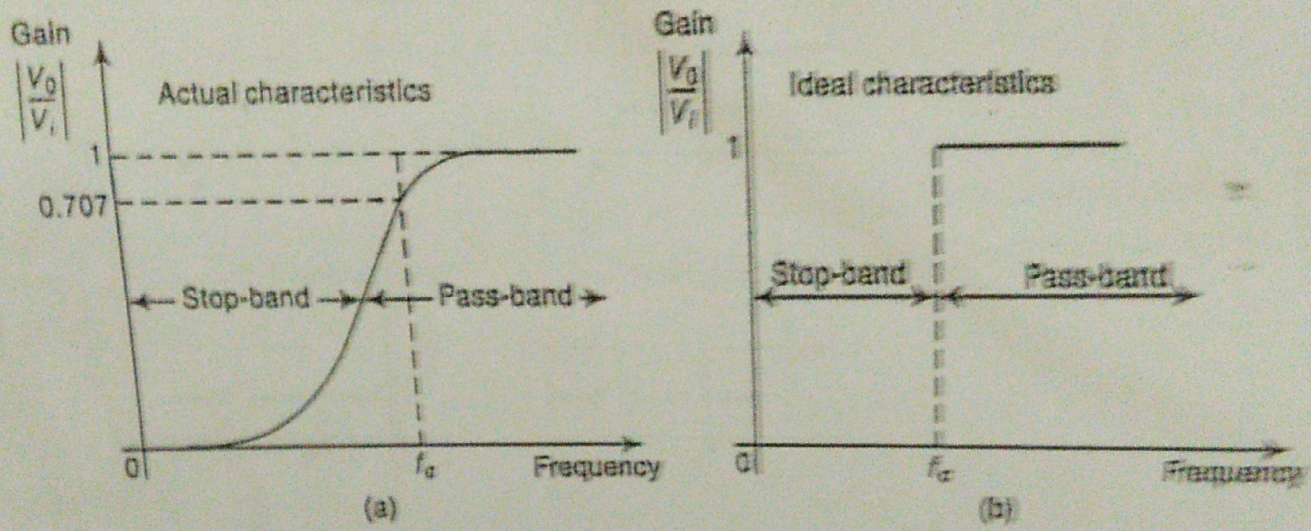


Fig: High pass filter characteristics (a) Actual (b) Ideal

3. **Band–Pass Filter** It is a circuit that passes a band of frequencies and attenuates all frequencies outside the band.

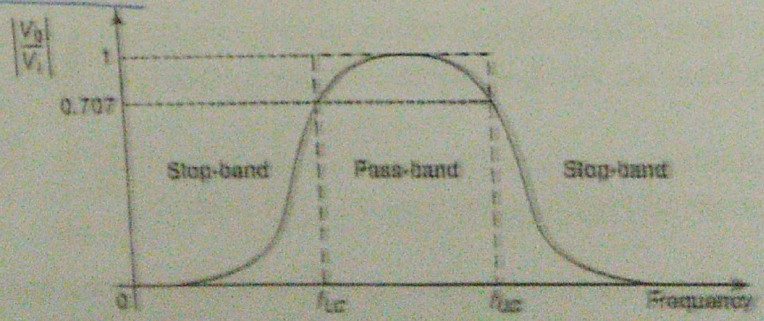


Fig: Band pass filter characteristics (Actual)

4. **Band-Rejection/Elimination Filter or Band Stop Filter or Notch Filter** it rejects specified band of frequencies while passing all other frequencies outside the band.

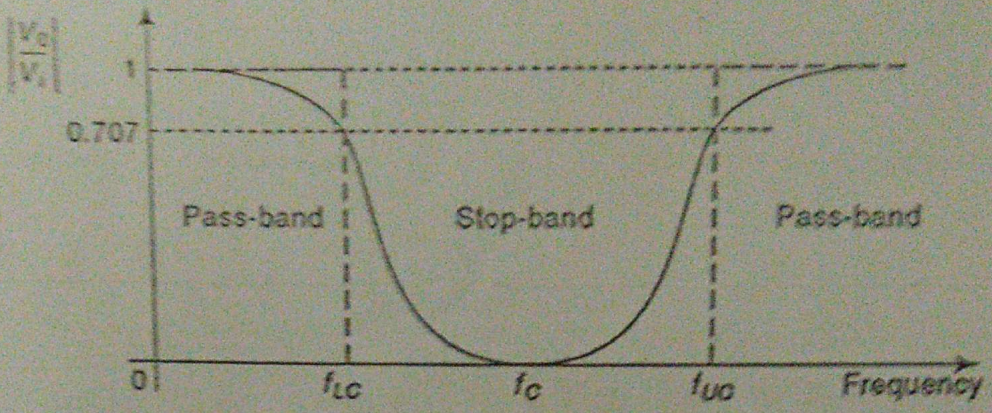


Fig: Band reject filter characteristics (Actual)

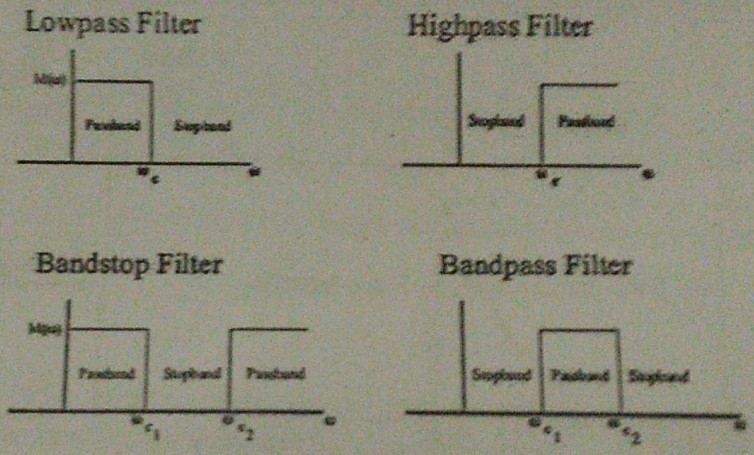


Fig: Ideal characteristics of filters

Low-pass filters cut off all high frequency parts of a signal, lower frequencies can pass the filter. Low-pass filters are closely related to smoothing procedures, such as moving averages.

High-pass filters cut off the low parts of the spectrum and let the high frequencies pass. High-pass filters are related to the first derivative of a function.

Band-pass filters are formed by a combination of low-pass and high-pass filters so that only frequencies within a certain range (band) can pass the filter.

...lter can be implemented both in analog and digital electronics.

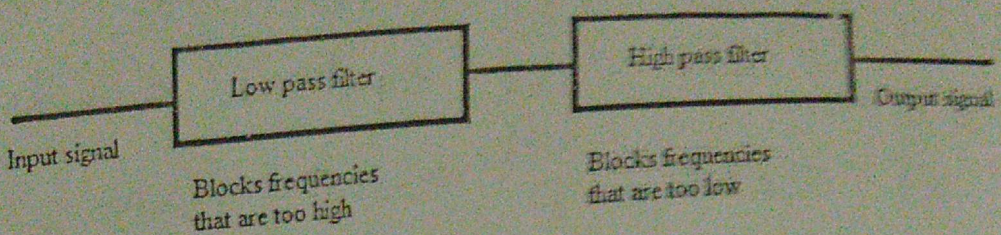


Fig: Band pass filter using LPF and HPF

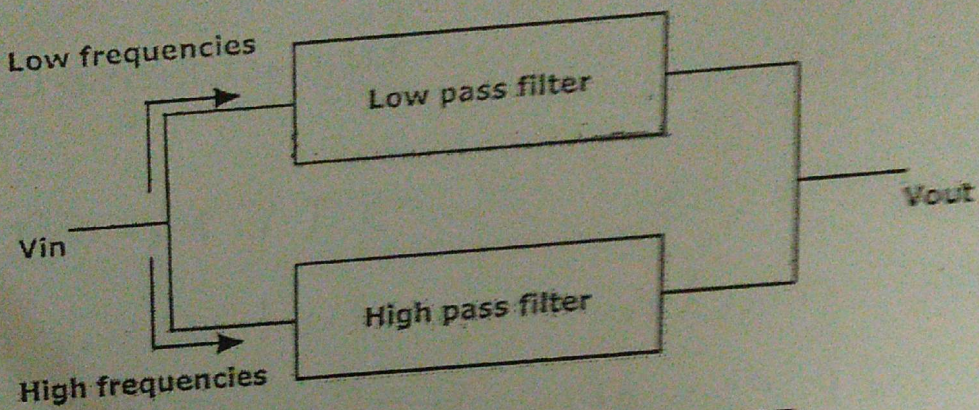


Fig: Band stop filter using LPF and HPF

Band pass filter can be constructed using LPF and HPF, by connecting both of them in cascade. Similarly, Band stop filter can be constructed using LPF and HPF, by connecting both of them in shunt (parallel) as shown above.

Questionnaire:

1. What is Amplitude Modulation?
2. What is Frequency Modulation?
3. What is meant by Modulation? Why is it necessary in Communication Systems?
4. What is Demodulation?
5. What are the different types of analog modulation techniques?
6. Mention the advantages and disadvantages of FM over AM?
7. What is Time-Division-Multiplexing?
8. What is Frequency-Division-Multiplexing?
9. Explain the classification of filters based on their frequency range of operation?
10. Explain the block diagram of a general communication system.