## DEPARTMENT OF INFORMATION TECHNOLOGY

## BLOCK DIAGRAM OF ANALOG COMMUNICATION

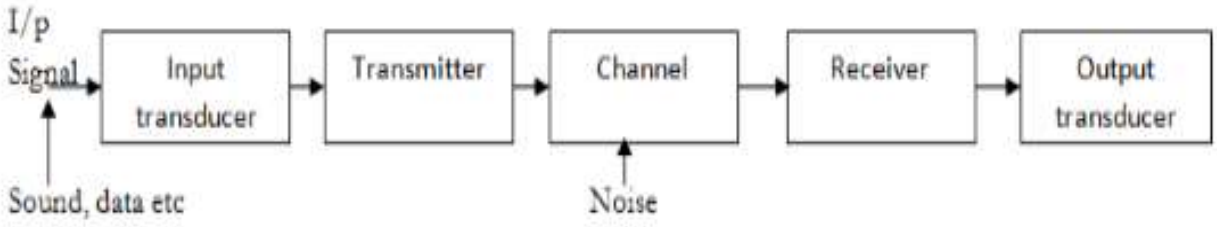



Fig: Basic analog communication system

- The elements of basic analog communication system are input signal or information, input transducer, transmitter, channel, Noise, Receiver, Output transducer.

**1.Information or Input signal:**

- The information is transmitted from one place to another.
- This information can be in the form of a sound signal like speech, or it can be in the form of pictures or it can be in the form of data information.

**2.Input transducer:**

- The information in the form of sound, picture or data signals cannot be transmitted as it is.
- First it has to be converted into a suitable electrical signal.
- The input transducer block does this job.
- The input transducer commonly used are microphones, TV etc.

**3.Transmitter:**

- The function of the transmitter is to convert the electrical equivalent of the information to a suitable form so that it can transfer over long distance.
- Basic blocks in transmitter are: Amplifier, Oscillator, Mixer.

**4.Channel:**

- The communication channel is the medium used for transmission of electrical signal from one place to other.
- The communication medium can be conducting wires, cables, optical fibres or free space.
- Depending on the type of communication medium, two types of communication system exist
- Line communication: The line communication systems use the communication medium like the simple wires or cables or optical fibres. Eg: Telephone, Cable TV.

- Radio communication: The radio communication systems use the free space as their communication medium. The transmitted signal is in the form of electromagnetic waves. E.g. Mobile communication, satellite communication.

**5.Noise:**

- Noise is an unwanted electrical signal which gets added to the transmitted signal when it is travelling towards the receiver.
- Due to noise quality of information gets degrade.
- Once added the noise cannot be separated out from the information

**6.Receiver:**

- The receiver always converts the modulated signal into original signal which consist of Amplifier, Oscillator, Mixer.

**7.Output transducer:**

- Output transducer converts electrical signal into the original form i.e. sound or TV pictures etc.
- E.g. Loudspeaker, data and image convertor.

## DEPARTMENT OF INFORMATION TECHNOLOGY

### Difference between Analog Communication and Digital Communication

| Sr. No. | ANALOG COMMUNICATION | DIGITAL COMMUNICATION |
|---|---|---|
| 01. | In analog communication analog signal is used for information transmission. | In digital communication digital signal is used for information transmission. |
| 02. | Analog communication uses analog signal whose amplitude varies continuously with time from 0 to 100. | Digital communication uses digital signal whose amplitude is of two levels either Low i.e., 0 or either High i.e., 1. |
| 03. | It gets affected by noise highly during transmission through communication channel. | It gets affected by noise less during transmission through communication channel. |
| 04. | In analog communication only limited number of channels can be broadcasted simultaneously. | It can broadcast large number of channels simultaneously. |
| 05. | In analog communication error Probability is high. | In digital communication error Probability is low. |
| 06. | In analog communication noise immunity is poor. | In digital communication noise immunity is good. |
| 07. | In analog communication coding is not possible. | In digital communication coding is possible. Different coding techniques can be used to detect and correct errors. |
| 08. | Separating out noise and signal in analog communication is not possible. | Separating out noise and signal in digital communication is possible. |
| 09. | Analog communication system is having complex hardware and less flexible. | Digital communication system is having less complex hardware and more flexible. |

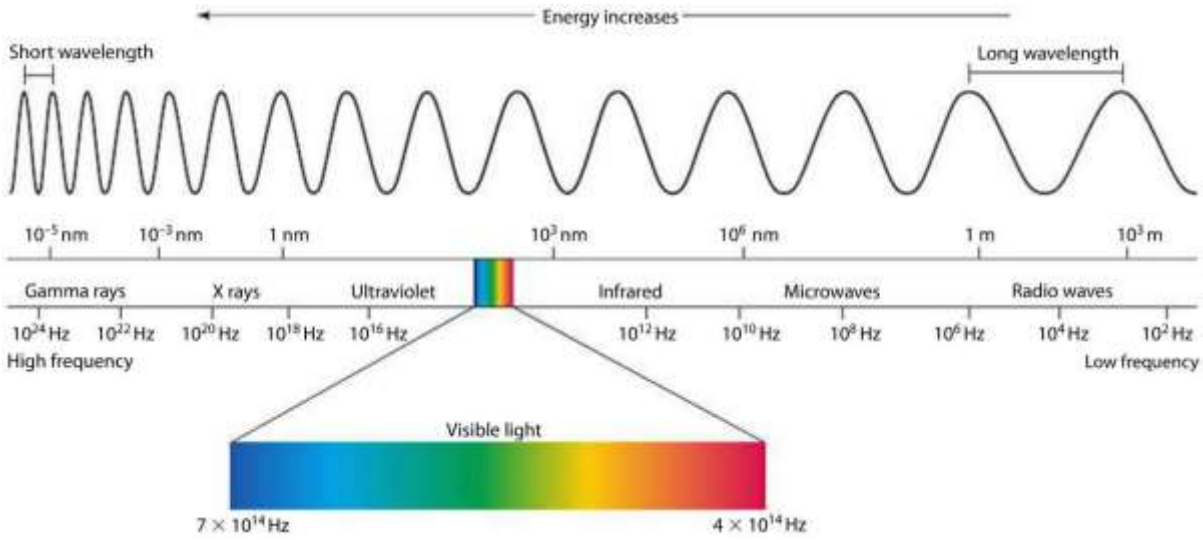
| Sr. No. | ANALOG COMMUNICATION | DIGITAL COMMUNICATION |
|---|---|---|
| 10. | In analog communication for multiplexing Frequency Division Multiplexing (FDM) is used. | In Digital communication for multiplexing Time Division Multiplexing (TDM) is used. |
| 11. | Analog communication system is low cost. | Digital communication system is high cost. |
| 12. | It requires low bandwidth. | It requires high bandwidth. |
| 13. | Power consumption is high. | Power consumption is low. |
| 14. | It is less portable. | Portability is high. |
| 15. | No privacy or privacy is low, so it is not highly secured. | Privacy is high, so it is highly secured. |
| 16. | Not assures an accurate data transmission. | It assures a more accurate data transmission. |
| 17. | Synchronization problem is hard. | Synchronization problem is easier. |

## DEPARTMENT OF INFORMATION TECHNOLOGY

## ELECTROMAGNETIC SPECTRUM

- Electromagnetic radiation comprises of oscillating electric and magnetic field components through which information transfer can occur.
- These oscillations are sinusoidal in nature and expressed in cycles per second or hertz (Hz).
- The range is of these oscillations is quite wide from as low as 1 Hz and can extend up to a large value.
- The entire range of the frequencies that the electromagnetic waves can produce is known as Electromagnetic Spectrum.
- The electromagnetic spectrum ranges from below the low frequencies which are used for radio communication to gamma radiation at the high-frequency, thereby covering wavelengths from thousands of kilometres down to a fraction of the size of an atom.
- Electromagnetic waves are distinguished by three physical properties, which are frequency f, wavelength λ and photon energy E.

### Electromagnetic Waves in Electromagnetic Spectrum




Radio waves, microwaves, infrared radiation, visible light, ultraviolet radiation, X-rays, gamma rays, and cosmic rays make up the full range (electromagnetic spectrum) in decreasing order of frequency and rising order of wavelength.

1. **Radio Waves**
   - The rapid travel of charged particles across conducting wires causes these waves.
   - Radio, television, and telecom signals are transmitted through them.
   - These waves have a frequency range of around 3kHz to 300MHz.
   - In the ultrahigh-frequency (UHF) band, cellular phones employ radio waves to convey voice communication.
   - Radio picks up radio waves that are broadcast by radio stations. Radio waves can be emitted by gases and stars in space. The majority of radio waves are used for TV and mobile communication.

2. **Microwaves**
   - Microwaves are a type of electromagnetic radiation that has a frequency of a few gigahertz (GHz).
   - Klystrons, magnetrons, and Gunn diodes are unique vacuum tubes that produce them.
   - Microwaves are commonly utilised in aviation navigation due to their short wavelengths.
   - These rays are employed in microwaves, which aid in the heating of meals in homes and offices. It's also used by astronomers to figure out and understand the structure of surrounding galaxies and stars.
3. **Infrared Rays**
   - Infrared waves are produced by hot bodies and molecules and are thus referred to as heatwaves.
   - Infrared rays are near the low-frequency or long-wavelength end of the visible light spectrum.
   - Night vision goggles make use of these radiations. Infrared light generated by objects in the dark can be read and captured by these devices. Infrared light is used to trace interstellar dust in space. Infrared radiation is emitted by electronic devices and is commonly employed in remote switches for a variety of household gadgets.
4. **Visible Rays**
   - Visible rays are electromagnetic waves that can be seen with the naked eye. They are the most common type of electromagnetic waves.
   - These can be found in the frequency range of $4\times10^{14}$Hz–$7\times10^{14}$Hz or the wavelength range of 400nm–700nm.
   - The visible light rays reflected or released from the objects around us assist us in seeing the world, and the range of visible radiation is different for different creatures.
   - Devices that emit light in the visible area of the electromagnetic spectrum include bulbs, lamps, candles, LEDs, tube lights, and so on.
5. **Ultraviolet Rays**
   - Although the sun is the primary source of ultraviolet radiation on Earth, the ozone layer absorbs the majority of UV energy before it reaches the atmosphere.
   - UV radiation has a wavelength of 400nm–1nm.
   - These radiations are emitted by special lamps and extremely hot bodies, and in big numbers, they can cause significant injury to humans. It tans the skin and creates burns.
   - Because these radiations may be focused on tiny beams, they are used in high precision applications such as LASIK or laser-based eye surgery.
   - UV lamps are used in water purifiers to eliminate microorganisms that may be present in the water.
   - When working with UV welding arcs, welders use special goggles to protect their eyes.
6. **X-Rays**
   - This electromagnetic radiation is found outside of the ultraviolet (UV) region of the electromagnetic spectrum and is extremely valuable in the medical field.
   - The wavelength range of X-ray radiation is 1nm–$10^{-3}$nm.
   - By blasting a metal target with high-energy electrons, X-rays can be produced.
   - X-rays are a diagnostic technique in medicine that can be quite helpful in the treatment of some types of cancer. To find the source of the problem, a doctor utilises

an x-ray scanner to scan our bones or teeth. Overexposure to x-rays can cause harm or death to the organism's healthy tissues. As a result, extreme caution must be exercised when dealing with x-rays.

- At the airport checkpoint, security agents utilise it to search through passengers' luggage. X-rays are also emitted by the universe's heated gases.

7. **Gamma-Rays**
   - The universe is the largest gamma-ray generator.
   - These rays are in the electromagnetic spectrum's higher frequency region.
   - Gamma rays have wavelengths ranging from $10^{-12}$m to $10^{-14}$m.
   - Radioactive nuclei release high-frequency radiations, which are also created during nuclear processes.
   - Gamma rays have a wide range of medical applications, including the destruction of cancerous cells. Gamma-ray imaging is a technique used by doctors to examine the insides of patients' bodies.

# PRINCIPLES OF COMMUNICATION

COURSE CODE: ITC304

SEM-IV

SONIA ANEESH

# DETAILS OF THE SUBJECT

- Course code: ITC304
- Theory (80 M end semester exam + 20 M Internal Assessment)
- Pre requisite for this subject

  a) Basic Electrical Engineering
- 6 modules in the syllabus
- Reference  Books

# TEXT BOOKS


1. George Kennedy, Bernard Davis, SRM Prasanna, Electronic Communication Systems, Tata McGraw Hill, 5th Ed.
2. Simon Haykin, Michael Moher, Introduction to Analog & Digital Communications, Wiley India Pvt. Ltd., 2nd Ed.
3. Wireless Communication and Networking, Vijay Garg

# COURSE OBJECTIVES

1. Study the basic of Analog and Digital Communication Systems.
2. Describe the concept of Noise and Fourier Transform for analyzing communication systems.
3. Describe the concept of Noise and Fourier Transform for analyzing communication systems.
4. Study the Sampling theorem and Pulse Analog and digital modulation techniques.
5. Learn the concept of multiplexing and digital band pass modulation techniques.
6. Gain the core idea of electromagnetic radiation and propagation of waves.

# Module 1
# Introduction

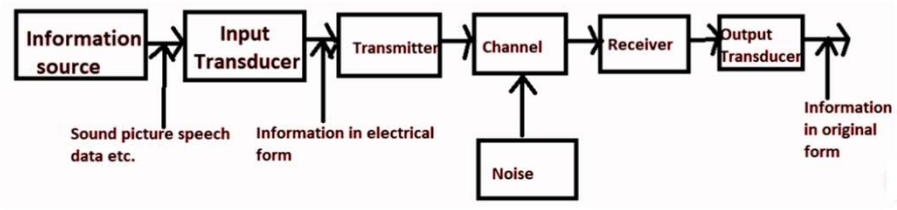
Parshvanath Charitable Trust's
A. P. SHAH INSTITUTE OF TECHNOLOGY
(Approved by AICTE New Delhi & Govt. of Maharashtra, Affiliated to University of Mumbai)
(Religious Jain Minority)

## Module-1- INTRODUCTION

| | | | | |
|---|---|---|---|---|
| **I** | **Introduction** | Basics of analog communication and digital communication systems (Block diagram), Electromagnetic Spectrum and application, Types of Communication channels.<br>**Self-learning Topics:** Applications areas of analog and digital communication. | **03** | **CO1** |

## Analog Communication: Block Diagram

- **Introduction to communication:** Communication is the process of establishing connection or link between two points for information exchange. Eg. Telephony, telegraphy, radio broadcasting, mobile communication, satellite communication etc.
- **1. Information Source:** This is the initial point from where any message or information gets originated. This message can be in the form of word, code, symbol, signal etc. The source produces the required message for the transmission.
- **2. Input Transducer:** The transducer converts any form of signal into electrical form i.e. a time varying electrical signal. Eg. Microphone converts signal of sound waves into corresponding electrical signals.
- **3. Transmitter:** The transmitter is used for modulation, range restriction and amplification of the signal. All these processing of the message signal are done to ease the transmission with the required amplitude and desired frequency

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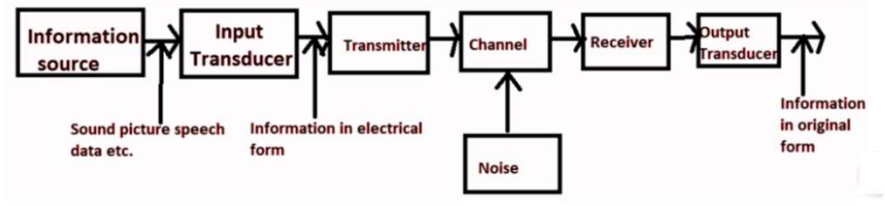
## Analog Communication: Block Diagram

- **4. Channel and Noise:** The channel is the medium through which message travels from transmitter to receiver. Channel can be point to point or broadcast depending on the applications. During the transmission through channel, the signal get distorted due to noise in the system. Noise is unwanted signal which interfere with the transmitted signal and reduce its power
- **5. Receiver:** The receiver reproduces the message signal in the electrical form from the distorted received signal. Demodulation is the reverse process of modulation which is used to reproduce the original message signal from the modulated signal
- **6. Output Transducer or Destination:** In this final stage, the electrical signal is converted into original form. In radio broadcasting, speakers converts the message signal into original sound signal

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## Source of Information:

- This is basically a signal which carries the information. This can be listed as:
- **1. Speech:** Transfer of information from speaker to end user
- **2. Music:** Music signal is produced from instruments such as piano, violin, flute etc. All musical signals have their fundamental frequency and overtones
- **3. Picture:** A picture or image signal consist of a brightness or colour signal, a function of two dimensional location. FAX machine send static pictures whereas Television produces dynamic or moving picture
- **4. Computer Data:** It is one of the digital transmission (a digital bit stream or a digitized analog signal)such as e-mails, software or file sharing

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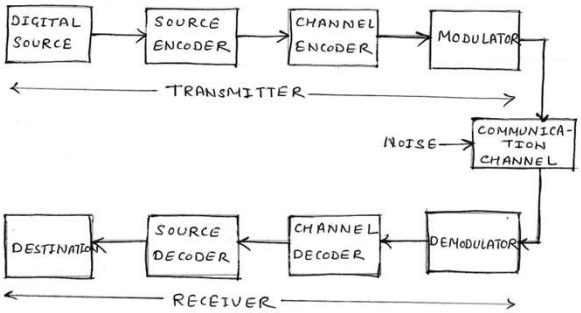
## Digital Communication: Block Diagram

- **Digital Source:** In digital communication, the source of information should be in digital form. If it is analog, it must be converted into digital. The source of information may be human voice, picture or any data
- By using pulse code modulation(PCM), analog information can be converted into digital data
- **Destination:** At the destination, original form of information is achieved. It may be human voice, picture or any data

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## Digital Communication: Block Diagram

- **Source Encoder:** It is used for efficiently representing source output. Most of the time data is compressed by source encoder. Eg. Huffman source coding, Shannon source coding
- **Source Decoder:** Source decoder function is exactly inverse of Source encoder. It is at receiver side, it extracts the original information
- **Channel Encoder:** The channel encoder is mainly used for error correction and error detection. Extra redundant bits are added in channel encoder to minimize the effect of channel noise. There are different techniques for channel encoding eg. Linear block codes, cyclic codes, convolutional codes
- **Channel Decoder:** The Channel decoder is at the receiver. Its function is exactly inverse of Channel encoder. The Channel decoder remove the extra bits added by Channel encoder. Channel encoder and Channel decoder provide a reliable communication over a noise channel
- **Modulation**: It is used for efficient transmission of signal over the channel. There are different modulation techniques like ASK, PSK,FSK, QPSK, FSK….. The demodulator is used to extract the original information from the modulated signal
- **Channel:** The channel is defined as the medium through which signal can be transmitted. Channels are classified into Coaxial cable. Telephone channel, optical fibre, radio(space) . Data rate of the signal depends on channel

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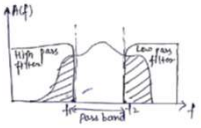
## Baseband and Bandpass Signal

- **Baseband signal** has a very narrow and near zero frequency range. It is synonymous with low pass or non modulated
- The electrical equivalent to original analog or digital signal is basically the baseband signal.

  All the voice or picture data comes under this category
- It is contained within the bandwidth, frequency close to 0 Hz upto higher cut off frequency
- **Bandpass signal :** A passband is the range of frequency that can pass through a filter. For eg. A radio receiver contains a bandpass filter to select the frequency of the desired radio signal out of all the radio waves picked up by its antenna
- A band passed filtered signal (i.e. signal with energy only in passband) is known as bandpass signal which has non zero lowest frequency in the spectrum
- Bandpass signal is obtained by shifting baseband signal in frequency domain which extends from f1 to f2 through modulation
- Passband transmission is typically utilised in wireless communication and in band passed filtered channels

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## Electromagnetic Spectrum

- **Frequency Spectrum Allocation:**
- It is the division of electromagnetic spectrum into radio frequency band
- The government of every country specify following things to regulate the things beyond national boundaries in a harmonise way : 1. Modulation type, 2. Bandwidth, 3. Power
- International Telecommunication Unit(ITU), defines frequency allocation as a given frequency band for the purpose of its use by one or more space radio communication services under specified conditions
- All members nation of ITU are free to decide the spectral usage and standard to be adopted by following the overall frequency plan
- For example, In America FCC(Federal Communication Committee) look frequency allocation while in INDIA, it comes under " National Frequency Allocation Plan"

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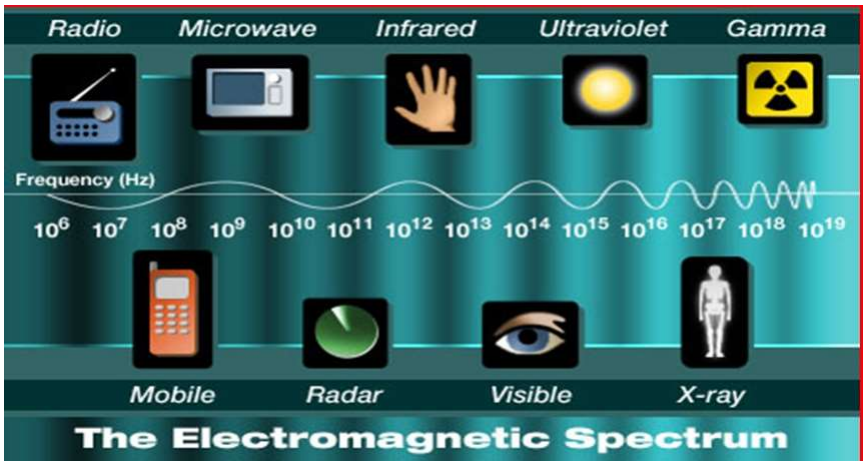
## Electromagnetic Spectrum

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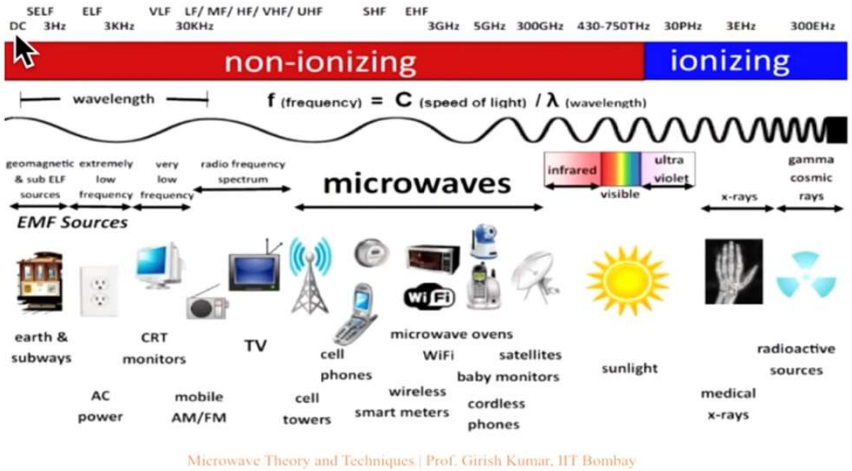
## Electromagnetic Spectrum




Microwave Theory and Techniques | Prof. Girish Kumar, IIT Bombay

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## Communication Channel

- There are various types of communication channels which makes the connection between the transmitter and receiver
- 1. Wireline channel, 2. Fiber optic channel, 3. Wireless electromagnetic channel, 4. Under water acoustic channel
- There are various reasons by which noise get added into the channel and results following signal changes:
  - a. signal attenuation
  - b. Amplitude and phase distortion
  - c. multipath distortion
- Though the noise can be reduced by :
  1. using large bandwidth,
  2. High transmitter power,

these two parameters decide maximum data rate which is practically possible to transmit

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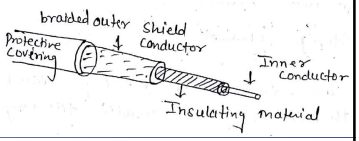
## Communication Channel

**1. Wireline Channel:** This consist of no. of copper wire such as telephone network which carry the signal

The two main types of wired channels are :A. **Coaxial Cables, B. Twisted pair cable**

- **A. Coaxial Cables:** It consist of inner conductor and braided outer shield conductor separated by dielectric material. Main wire consist of one or more than one coaxial cable that can carry 10,000 voice channels at a time. It is also used to transmit the digital data in the range of 8.5 MBPS to 565 MBPS. It has various applications like cable MODEM, Ethernet LAN etc.
- **Characteristics of Co-axial cable:**
- It has excellent noise immunity duo to shielded protective layer
- It has low losses due to large bandwidth
- It has the signal attenuation of 200 dB per 150m at 1 GHz
- It is mainly used for Local Area Network(LAN)due to point to point and multipoint connections
- It also provide access to ISDN(Integrated Service Digital Network)

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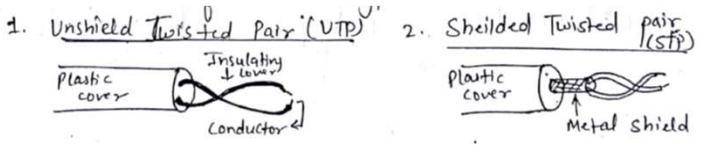
## Communication Channel

- **Twisted Pair cable: This is a type of wiring in which two conductors of single circuit are twisted together for the purpose of cancelling out electromagnetic interreference(EMI) from external sources. These are of two types: 1. Unshielded Twisted Pair(UTP), 2. Shielded Twisted Pair(STP)**
- **Now a days STP, are used because UTP are cheap but badly affected by noise temperature**
- **STP are protected by metal shield so as to cover each pair of twisted insulating conductors**
- **STP are bulky and expensive because metal shield is connected to ground to reduce the effect of noise**
- **It can be used for analog as well as digital communication but bandwidth depends on the thickness of the wire**

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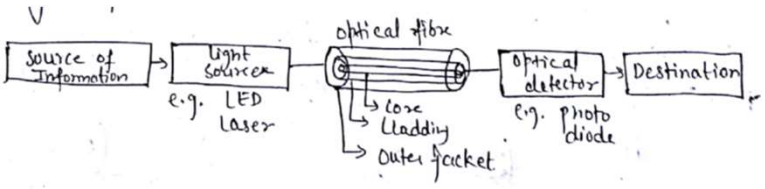
## Communication Channel

- **2. Fiber Optic Channels**: Fiber optic is a high speed network( approx. 128 GByte per sec data rate)
- The computer data and information is converted into light for transmission within data centres
- **Characteristics of Optical fiber :**
- High data rate due to higher bandwidth
- Better signal quality due to high S/N ratio and low noise interreference
- Small size and light weight
- Used for point to point communication (LAN)

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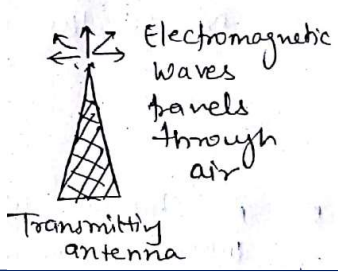
## Communication Channel

- **3. Wireless Electromagnetic Channel**: Here the signal is transmitted through air in a directed way which is received by antenna
- There are 3 propagation which takes place:
- Ground Wave propagation(30 KHz – 3 MHZ)
- Sky Wave propagation (3 MHz – 30 MHZ)
- Space Wave propagation (30 MHZ onwards)
- The physical size of antenna depend primarily on frequency of operation

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## Communication Channel

- **4. Underwater acoustic Channels:**
- EM wave can propagate under water at low frequency for very short distance
- As the under water activities takes place, the data must be collected through sensors which is transferred to surface
- The distance over which the signal is attenuated by 1/e is called Skin Depth ($\delta$), this term express the attenuation of EM waves
- $\delta = \frac{\delta_0}{\sqrt{f}}$ ; $\delta$= Skin depth, f = frequency
- A shallow water acoustic channel is multipath where signal get distributed in different directions with signal delay that may result in signal fading (Due to reflection of two surfaces: water and earth)
- The noise in signal is also created by sea water animals and nearby area
- The path of sound waves are refracted depending on velocity variation and frequency variation

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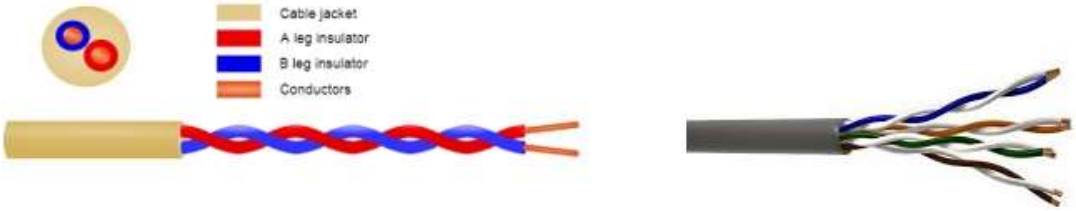
## DEPARTMENT OF INFORMATION TECHNOLOGY

### TYPES OF CHANNELS

- The Channel provides the electrical connection between the source and destination. It is a physical path between transmitter and receiver.
- A transmission medium (plural transmission media) is a material (solid, liquid or gas) which can propagate energy waves. For example, the transmission medium for sound received by the ears is air.
- The quality of transmission is determined by both the characteristics of the medium and the characteristics of the signal.
- There are two physical ways to transmit data: guided and unguided.
- **Guided media** consists of physical connection between source and destination via a wire or a cable. In guided media, the signals are confined within the wire and guided along a physical path. Examples are twisted pair, coaxial cable and optical fiber.
- **Unguided media** transport electromagnetic (EM) waves without using a physical conductor. This type of communication is often referred to as wireless communication. Examples are atmosphere and outer space (Radio waves, microwaves, infrared) and satellite channels.
- Unguided (wireless) transmission is used in geographically disadvantaged places like: desert, forest, hills, mountains, oceans etc., where installing wires, cables is difficult.

### Twisted Pair cable

Wire pairs are commonly used in local telephone communication and for short distance digital data communication. They are usually made up of copper and the pair of wires is twisted together. Data transmission speed is normally 9600 bits per second in a distance of 100 meter.




### Coaxial cable

Coaxial cable consists of a central copper wire surrounded by an insulation over which copper mesh is placed. Coaxial cable is like a pipe with wire suspended in the middle of it. Due to its construction, coaxial cable is less susceptible to interference than twisted pair. Coaxial cable is capable of supporting a much higher frequency range than twisted pair.

One of the most popular use of co-axial cable is in cable TV (CATV) for the distribution of TV programmes. Another importance use of co-axial cable is in LAN and for long distance telephone communication.

Commonly used medium and it is quite cheaper than any other transmission media. A twisted pair consists of two insulated conductors twisted together as shown in figure. Twisting is used to decrease interference from other wires.

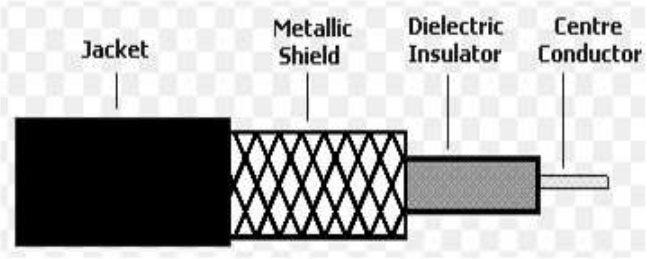
It can be shielded (cover for extra protection) or unshielded. The unshielded twisted pairs are very cheap and easy to install, but badly affected by noise and interference.

Two types of cables having 75 ohm and 50-ohm impedance are available

Because of shielding, this cable has excellent noise immunity

It has a large bandwidth and low losses

These cables are costlier than twisted pair cables, but cheaper than optical fibre cables





**Fibre Optic cable**

An optical fiber is constructed from a very thin stand of glass or ultra-pure plastic that is placed in a cladding of glass or plastic. Information is transmitted in the form of light, therefore no electrical interference and supports long distance communication. Note that twisted-pair cable, coaxial cable transport signals in the form of electric signals. Fibre optic operates at optical frequencies (1014 to 1015 Hz). A fiber optic cable consists of a bundle of glass threads. The main disadvantage of fiber optics is that the cables are expensive to install.

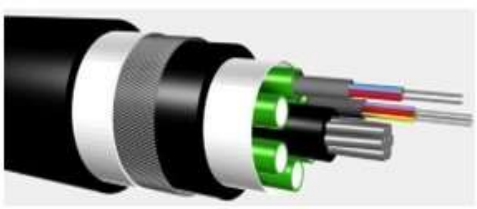
Because of greater bandwidth (2Gbps), smaller diameter, lighter weight, low attenuation, immunity to electromagnetic interference (EMI) and longer repeater spacing, optical fiber cables are finding widespread use in long-distance telecommunications.

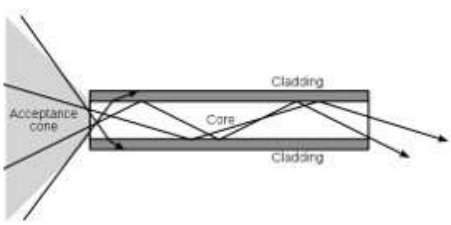
Fibre optic carries information in the form of light

Fiber optic cables have a much greater bandwidth than metal cables. This means that they can carry more data.

Fiber optic cables are less susceptible to interference than other transmission medium.

Fiber optic cables are much thinner and lighter than wires





**Wireless Electromagnetic channels**:

In radio communication systems, the transmitter radiates its output in the form of electromagnetic waves using transmitting antenna.

These waves travel towards the receiver through free air which acts as a communication channel.

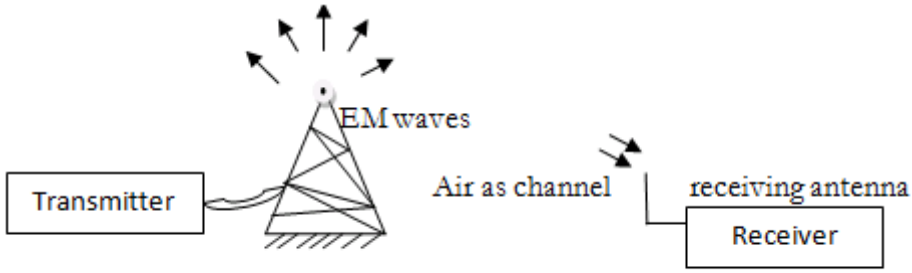



Fig: Wireless electromagnetic channel

**Underwater Acoustic channels:**

The underwater communication is required when oceans are being explored.

The data collected by the sensors placed underwater should be transmitted first to the surface and then to the data collection center.

**Storage channels:**

The magnetic tapes, digital audio, video tapes, magnetic disks are used for storing large amount of computer data.

Optical disks are used for storing the computer data, music and video information.

All these data storing systems can be characterised as Storage channels.