Unit-3
Introduction to Physical Layer

The **physical layer** is the first and lowest layer in the OSI (Open Systems Interconnection) model of computer networking.

• It is responsible for the transmission and reception of unstructured raw data between a device and a physical transmission medium.
• It defines the hardware elements involved in the process of data transmission, including cables, switches, network interface cards, and more.
• It deals with the electrical, mechanical, and procedural interfaces to the physical medium, ensuring that data is transmitted in a bit stream format.

Key Functions of the Physical Layer:

- It transfers data bit by bit or symbol by symbol.
- It converts digital data into analog signals or vice versa.
- It handles simplex, half-duplex, and full-duplex transmission modes.
- It defines the physical layout and arrangement of devices in the network.
- It performs bit synchronization, which means that only one bit needs to be transferred from one system to another at a time.

What is Analog Communication?

In Analog communication the data is transferred with the help of analog signal in between transmitter and receiver. Any type of data is transferred in analog signal. Any data is converted into electric form first and after that it is passed through communication channel. Analog communication uses a continuous signal which varies in amplitude, phase, or some other property with time in proportion to that of a variable.

Advantages of Analog Signals

- It is Easier in processing.
- Analog Signals are best fitted to audio and video transmission.
- It has a coffee cost and is portable.
- It posses higher density.

Disadvantages of Analog Signals

- Analog tends to possess a lower quality signal than digital.
- The cables are sensitive to external influences.
- Analog wire is expensive and not easily portable.

What is Digital Communication?

In Digital communication digital signal is used rather than analog signal for communication in between the source and destination. The digital signal consists of discrete values rather than continuous values. In digital communication physical transfer of data occurs in the form of digital bit stream i.e 0 or 1 over a point-to-point or point-to-multipoint transmission medium. In digital communication the digital transmission data can be broken into packets as discrete messages which is not allowed in analog communication.

Advantages of Digital Communication

- The speed of data transmission is quite high therefore, message transfer occurs almost instantly.
- The process of digital communication is quite efficient because speed and accuracy are always maintained in this system.
- The wireless nature of digital communication can be used to establish connections globally without major geographical constraints.

Disadvantages of Digital Communication

- Digital Communication lacks a personal touch due to a lack of proper interaction between users at both the ends of channel.
- With an increase in network coverage, the complexity of digital communication systems increases and therefore, implementation of such circuits is difficult.

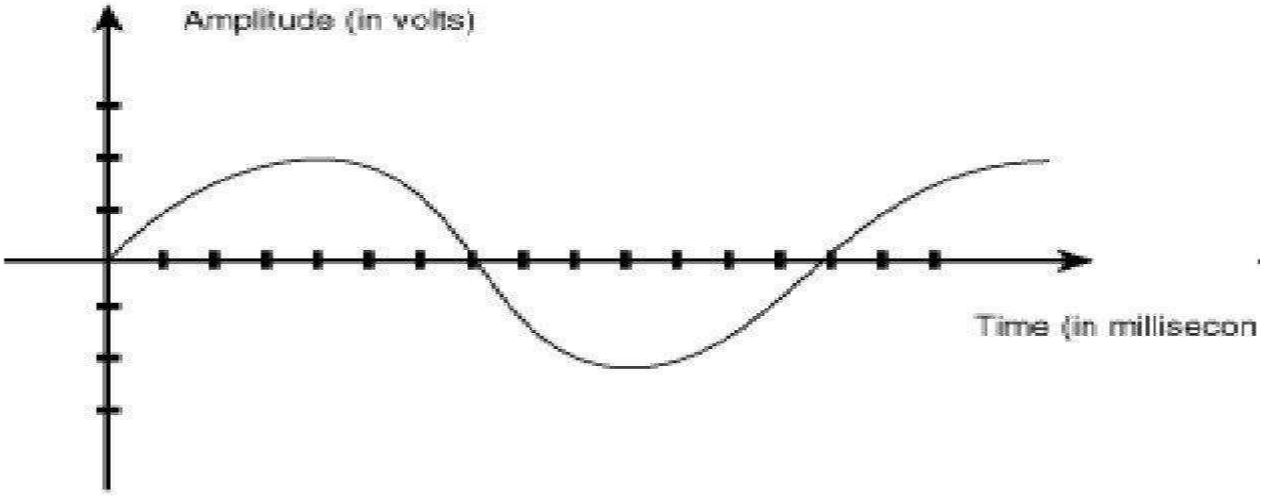
What is Signal?

A Signal is an electromagnetic wave that is used **to** communicate system-to-system by sending data from one network to another network is basically known as **"Signal"**.
In a computer network there are mainly two types of signals are:

1. Analog Signal
2. Digital Signal

What is Analog Signal?

An Analog signal is a signal which is continuous and has a time-varying feature. It is a representation of time-varying quantity. For example, the Human voice can be considered an analog signal because the signal of the human voice flows in a continuous manner.



Analog Signal

In other words, we can say that the analog signal is represented by the continuous variable which transmits the information/data as a response to physical phenomenon. It is known as an **"Analog Signal"**

Examples of digital signals are **Temperature, Pressure, Flow Measurement**, etc.

Types of Analog Signal

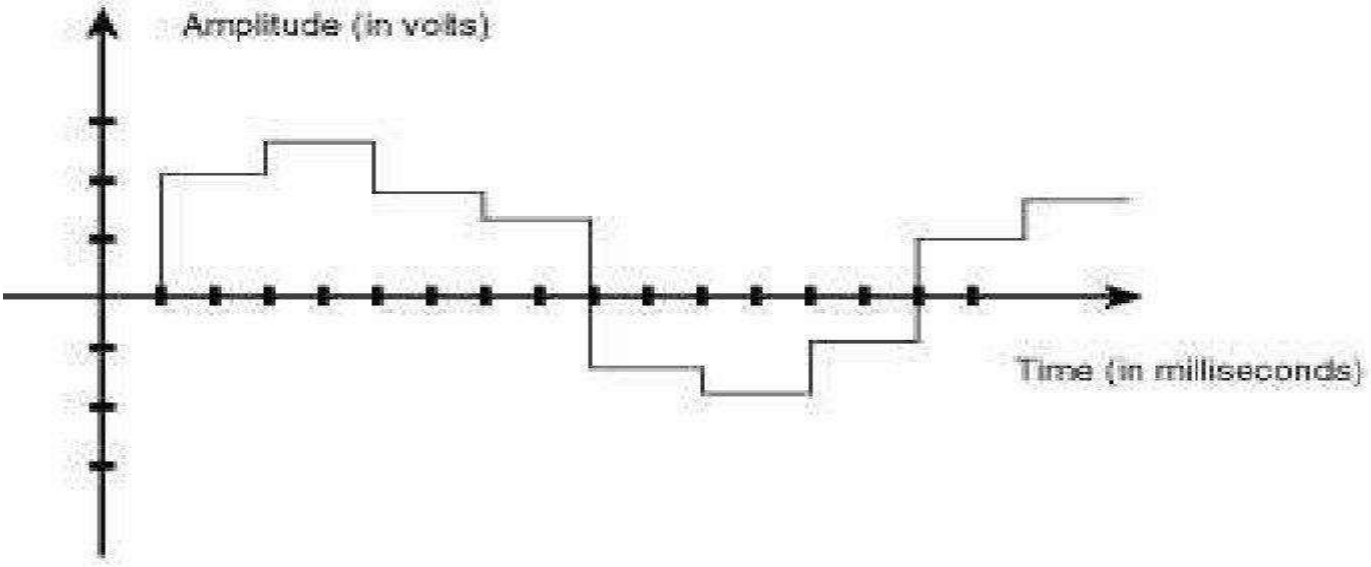
1. Simple Analog Signal
2. Composite Analog Signal

What is Digital Signal?

As the word suggests **"Digital"** which means it describes the electronic technology that generates signals. It is a physical signal that is represented by two discrete values "0" & "1", these discrete values are known as bitstream.

(If you want to know more about these discrete values then you should read our this article: What is the difference Between Bit and Byte?

In simple words, we can say that the binary signals are known as "Digital signals" where the signals are converted into a small bit form which is represented by a series of "0" & "1".



Difference between Analog and Digital Signal

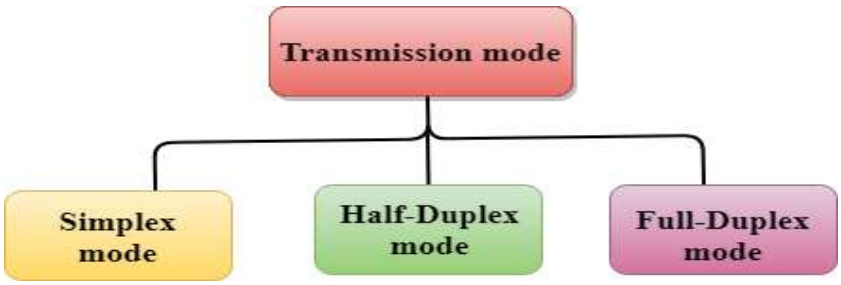
	Analog Signal	**Digital Signal**
Signal	1) In an Analog, signals are continuous.	1) In a Digital, Signals are discrete.
Transformation	2) In analog systems electronic circuits are used for the transformation of signals.	2) In Digital Signals, the transformation is done using the logic circuit.
Transmission	3) Data transmission is not of high quality.	3) Data transmission has high quality.
Flexibility	4) In an Analog signal, their hardware is not flexible.	4) In Digital signals, their hardware is not flexible.
Noise	5) Analog signals are more likely to get affected and result in reduced accuracy.	5) Digital signals are discrete time signals that are generated by digital modulation.

	Analog Signal	Digital Signal
Power Consumptions	6) Analog signals use more power.	6) Digital signals use less power compared to analog.
Waves	7) It is denoted by the sine waves.	7) It is denoted by the square form.
Example	8) Human Voice, Tape recorder, Temperature, etc.	8) Mp3 players, Digital phones, computers, etc.

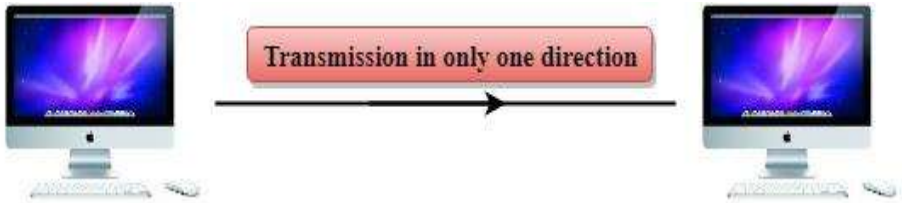
Transmission modes

- The way in which data is transmitted from one device to another device is known as **transmission mode**.
- The transmission mode is also known as the communication mode.
- Each communication channel has a direction associated with it, and transmission media provide the direction. Therefore, the transmission mode is also known as a directional mode.
- The transmission mode is defined in the physical layer.

The Transmission mode is divided into three categories:



Simplex mode



- In Simplex mode, the communication is unidirectional, i.e., the data flow in one direction.

- A device can only send the data but cannot receive it or it can receive the data but cannot send the data.
- Keyboard and Monitor are the examples of the simplex mode as a keyboard can only accept the data from the user and monitor can only be used to display the data on the screen.

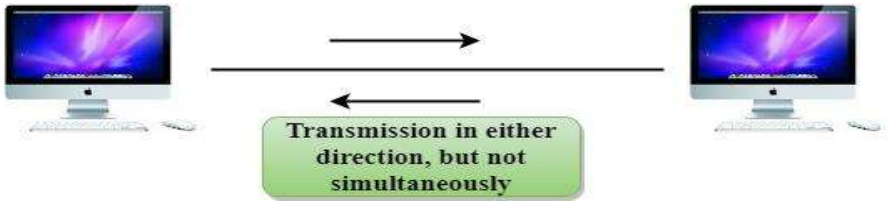
Advantage of Simplex mode:

- In simplex mode, the station can utilize the entire bandwidth of the communication channel, so that more data can be transmitted at a time.

Disadvantage of Simplex mode:

- Communication is unidirectional, so it has no inter-communication between devices

Half-Duplex mode



- In a Half-duplex channel, direction can be reversed, i.e., the station can transmit and receive the data as well.
- Messages flow in both the directions, but not at the same time.
- A **Walkie-talkie** is an example of the Half-duplex mode. In Walkie-talkie, one party speaks, and another party listens. After a pause, the other speaks and first party listens. Speaking simultaneously will create the distorted sound which cannot be understood.

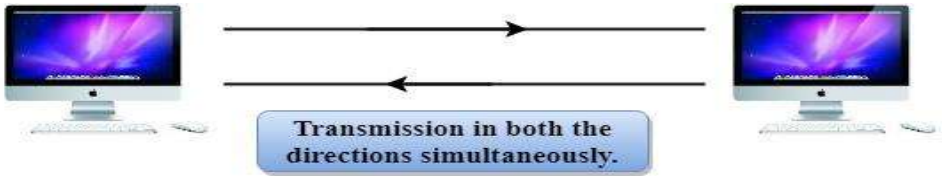
Advantage of Half-duplex mode:

- In half-duplex mode, both the devices can send and receive the data and also can utilize the entire bandwidth of the communication channel during the transmission of data.

Disadvantage of Half-Duplex mode:

- In half-duplex mode, when one device is sending the data, then another has to wait, this causes the delay in sending the data at the right time.

Full-duplex mode



- In Full duplex mode, the communication is bi-directional, i.e., the data flow in both the directions.
- Both the stations can send and receive the message simultaneously.
- The Full-duplex mode is the fastest mode of communication between devices.
- The most common example of the full-duplex mode is a telephone network. When two people are communicating with each other by a telephone line, both can talk and listen at the same time.

Advantage of Full-duplex mode:

- Both the stations can send and receive the data at the same time.

Disadvantage of Full-duplex mode:

- If there is no dedicated path exists between the devices, then the capacity of the communication channel is divided into two parts.

What is Modulation?

The process of superimposing a message signal on a carrier signal so that the message can be transmitted over long distances is called **modulation**. Here, the carrier signal is the signal of high frequency which is used to carry the message signal. The following figure shows the block diagram of modulation.

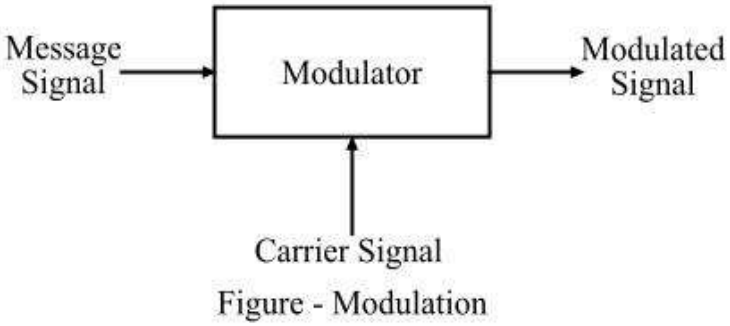
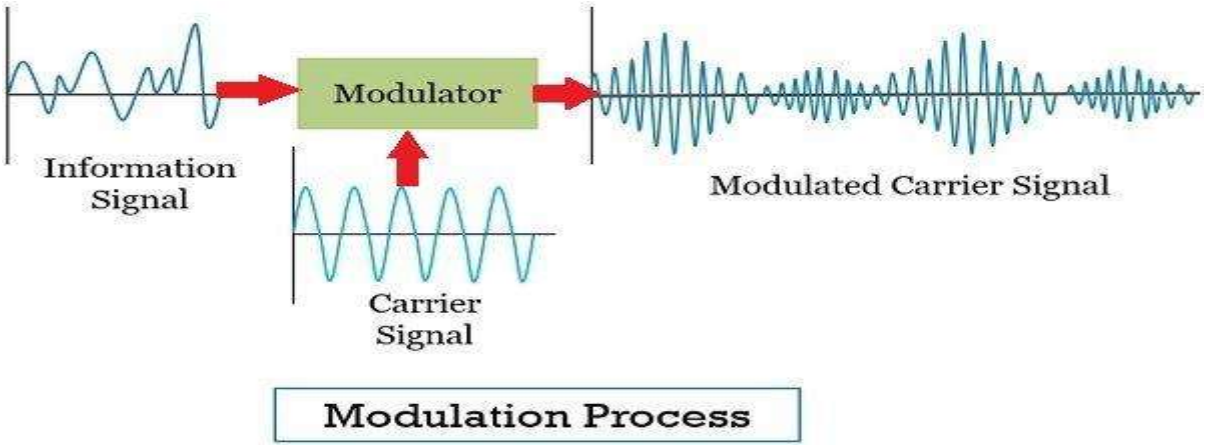
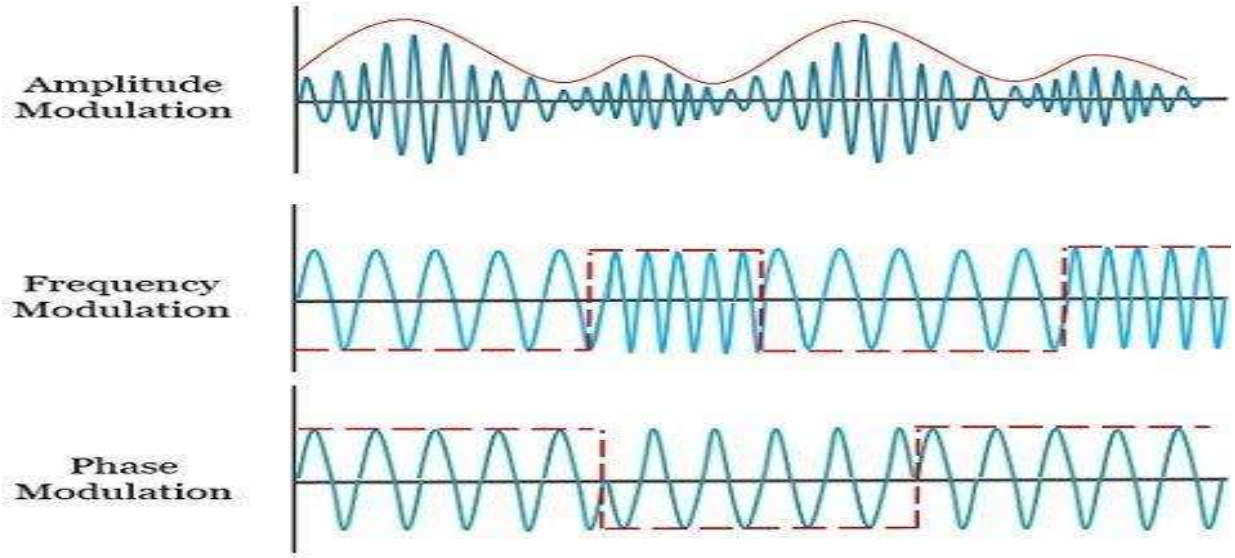


Figure - Modulation



Types of Modulation:

- **Amplitude Modulation (AM)**: Varies the amplitude (strength) of the carrier signal.
- **Frequency Modulation (FM)**: Varies the frequency of the carrier signal.
- **Phase Modulation (PM)**: Varies the phase of the carrier signal.



Types of Analog Modulation

What is Demodulation?

The process of obtaining the original message from the modulated signal is called **demodulation**. In simple words, demodulation is the process of separating a message signal from a carrier signal. The process of demodulation is shown in the following block diagram.

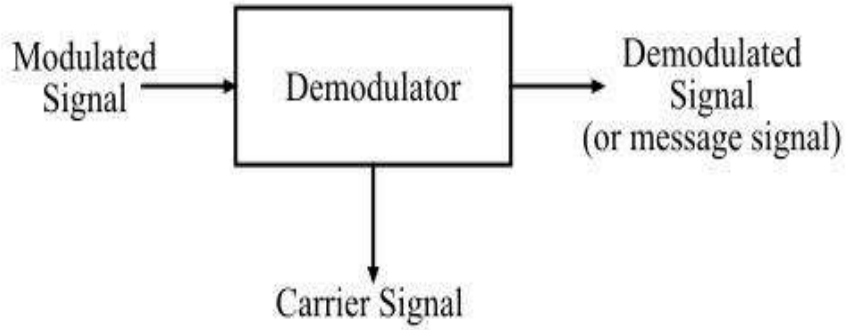
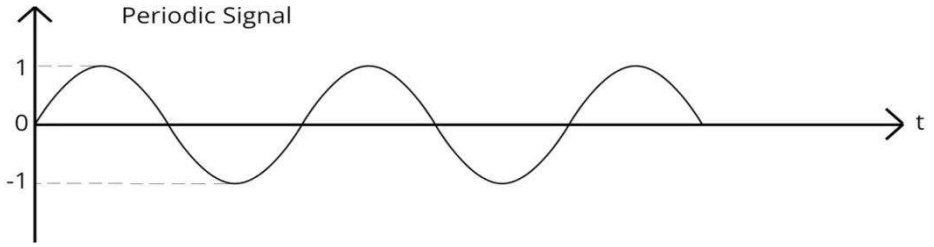
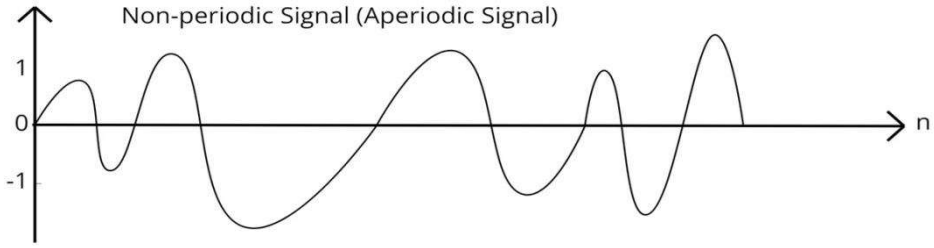


Figure - Demodulation

What are Periodic & Aperiodic signals

SR. NO.	PARAMETER	PERIODIC SIGNAL	NON-PERIODIC SIGNAL
1	**Explanation**	A periodic signal is a type of signal that repeats at regular intervals. Periodic signals are characterized by a constant frequency and may have a constant or varying amplitude.	Non-periodic signals, also known as aperiodic signals, do not repeat at regular intervals. Aperiodic signals may have varying frequencies and amplitudes, and may have complex or irregular waveforms.
2	**Repetition**	Periodic signals repeat at regular intervals.	Non-Periodic signals do not repeat.
3	**Frequency**	Periodic signals have a constant frequency.	Non-Periodic signals may have varying frequencies.
4	**Amplitude**	Periodic signals may have a constant or varying amplitude.	Non-Periodic signals may have a constant or varying amplitude.
5	**Waveform**	Periodic signals have a repeating waveform.	Non-Periodic signals may have a complex or irregular waveform.
7	**Energy**	Periodic signals have energy concentrated at specific frequencies.	Non-Periodic signals may have energy distributed over a range of frequencies.
8	**Time Domain Representation**	In the time domain, periodic signals appear as repeating waves.	Non-Periodic signals may appear as random or chaotic.
11	**Application**	Periodic signals are commonly used in communication and control systems.	Non-Periodic signals are used in audio and image processing, and in the study of chaotic systems.
12	**Example**	Examples of periodic signals include sine waves, square waves, and triangle waves.	Examples of Non-Periodic signals include noise, music, and speech. Non-periodic signals are commonly used in audio and image processing, and in the study of chaotic systems.


Periodic Signal
1
0
-1
t


Non-periodic Signal (Aperiodic Signal)
1
0
-1
n