Unit 3
Physical Layer

Introduction;

The physical layer is the foundation of any networks and provides framework for network architecture. The physical layer is the network hardware which includes servers, clients, and circuits. Here we focus on the **circuits** and on how clients and servers **transmit data** through them. The circuits are usually a combination of both physical media (e.g., cables, wireless transmissions) and special-purpose devices that enable the transmissions to travel through the media. The special-purpose devices are hubs, switches, and routers.

The physical layer coordinates the functions required to transmit a **bit stream** over a physical medium.

Some functions of physical layer are:

1. **Physical characteristics of interfaces and media**: physical layer defines the characteristics of interface between devices and transmission medium.
2. **Representation of bits**: bit stream must be encoded to signals. Physical layer defines the type of encoding.
3. **Data rate or transmission rate**: number of bits sent each second is data rate. It is defined by physical layer.
4. **Synchronization of bits**: sender and receiver must be synchronized at bit level.

Data and signals

Data and signals can be in analog or digital form.

Analog and Digital Data

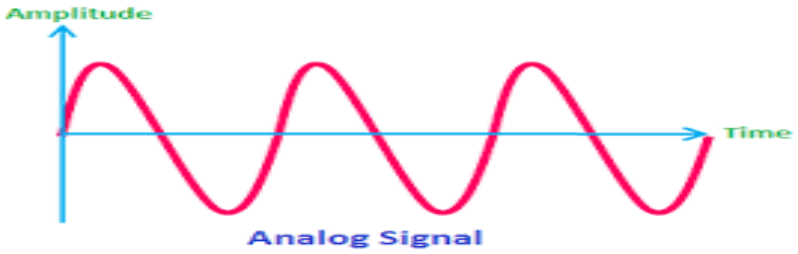
Analog data are continuous values. For e.g. analog clock has hour, minute, and second hands which gives information in continuous form, i.e. movements of hands is continuous.

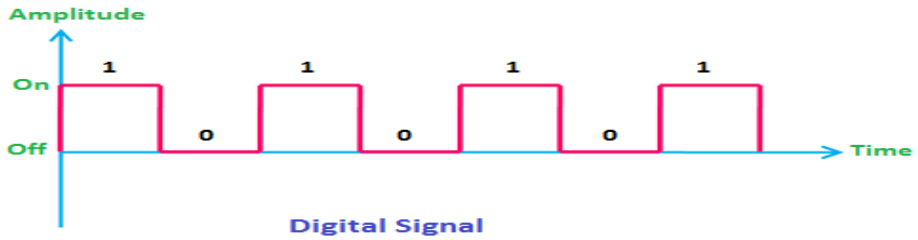
Digital data have discrete values. In a digital clock the time will suddenly change from 11:50 to 11:51.

Analog and Digital Signals

When data (analog or digital data) is to be sent over a medium first it need to be converted into electromagnetic signals. The data can be either a plain text or audio or video or file on a disk, it must be converted in the form of signals.

Both digital and analog data can be represented in the form of digital or analog signals.





Analog Signals

It is the continuous signal which varies in smooth fashion. The range occupied by it doesn't keep absolute value but the continuous wave. Analog signals are in the form of a continuous time-varying physical quantity, such as voltage magnitude or frequency, that reflects the variations of the information or signal source with time.

Analog signals are of two types:

a) **Simple Analog Signal**
b) **Composite Analog signal**

A **simple analog signal** is smooth, consistent and continuous. Sine wave represents a simple analog signal which is also known as periodic analog signal. Repetition of same signal patterns over a time is periodic signal. Sine wave has three parameters.

a) Amplitude
b) Period and Frequency
c) Phase

Amplitude is the strength of signal. It is measured in voltage, Ampere etc. Amplitude is denoted by **A.**

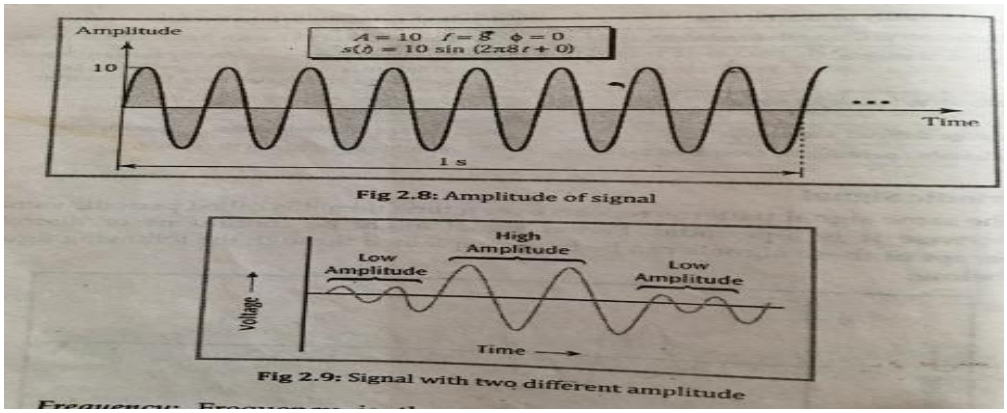


Fig 2.8: Amplitude of signal

Fig 2.9: Signal with two different amplitude

Period is the amount of time (in seconds) a signal takes to complete one cycle. It is denoted by T. **Frequency** is the rate at which signal repeats. It is measured in terms of Cycle per Second (CPS) or Hertz (Hz). It is denoted by f. Mathematically, T=1/f.

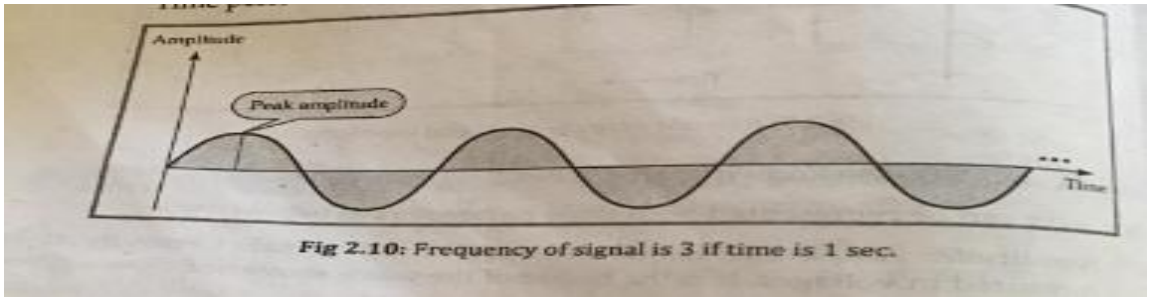


Fig 2.10: Frequency of signal is 3 if time is 1 sec.

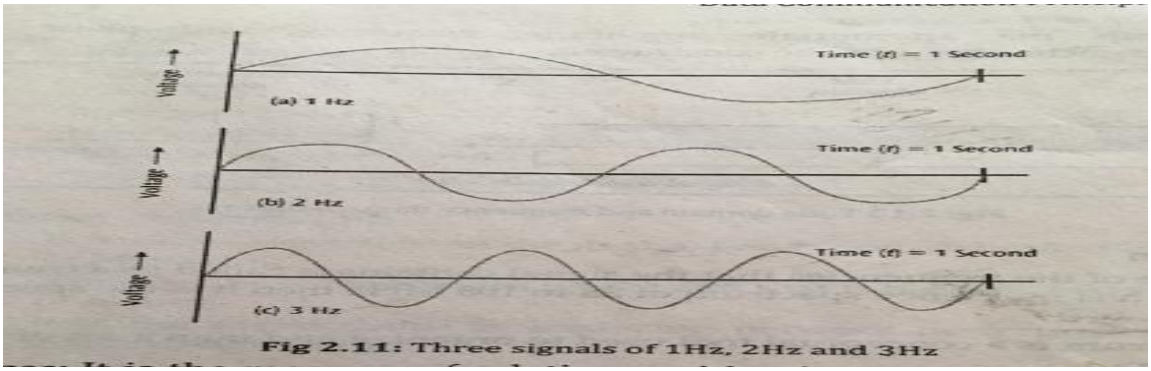


Fig 2.11: Three signals of 1Hz, 2Hz and 3Hz

Phase is the measure of relative position in time within single period of signal. It indicates the status of the first cycle. Change in phase can be any number of angels in between 0^0 to 360^0. It is measured in radiant or degree and denoted by Ø.

Mathematically, S (t) =A sin ($2\pi ft+ Ø$)

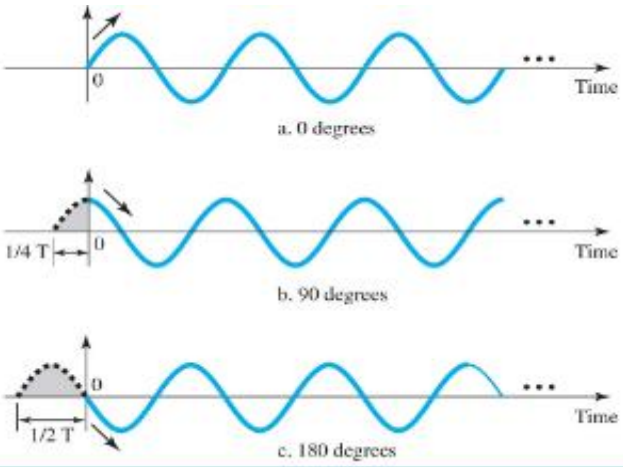


Fig: Three sine wave with same amplitude and frequency but different phase

According to above figure we can say:

A sine wave with phase 0^o starts at time 0 with zero amplitude, amplitude is increasing. A sine wave with phase 90^o starts at time 0 with peak amplitude & amplitude is decreasing. A sine wave with phase 180^o starts at time 0 with a zero amplitude. The amplitude is decreasing.

Also, a sine wave with a phase 0^o is not shifted. A sine wave with phase 90^o is shifted to the left by ¼ cycle and a sine wave with 180^o is shifted left by ½ cycle , however note that signal does not really exist before time 0.

Composite Signal: A single-frequency sine wave (simple sine wave) is not useful in data communications; we need to change one or more of its characteristics to make it useful. When we change one or more characteristics of a signal, i.e. single--frequency signal, it becomes a composite signal made of many frequencies. A composite analog signal is not smooth and consistent like simple analog signal.

A composite signal can be periodic or non-periodic. A periodic composite signal can be decomposed into a series of simple sine waves with discrete frequencies, frequencies that have

integer values (1, 2, 3, and so on). A non-periodic composite signal can be decomposed into a combination of an infinite number of simple sine waves with continuous frequencies, frequencies that have real values.

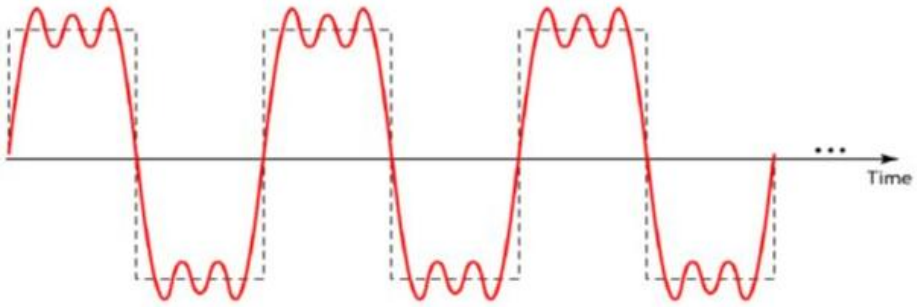


Fig: composite periodic signals

Digital Signals

A digital signal is a signal that is used to represent data as a sequence of separate values at any point in time. It can only take on one of a fixed number of values. This type of signal represents a real number within a constant range of values. Signal intensity maintains a constant level for some period of time and changes to another constant level.

Q. Differentiate between Analog and digital signal.

Circuits

Circuit Configuration

Circuit configuration is the basic physical layout of the circuit. There are two fundamental circuit configurations:

i. **Point-to-point circuit**
ii. **Multipoint Circuit**

Point-to-point circuit

A point-to point circuit provides a dedicated link between two devices. The circuit is dedicated to the use of these two computers. This type of configuration is used when the computers generate enough data to fill the capacity of the communication circuit. When an organization builds a network using point-to-point circuits, each computer has its own circuit running from itself to the other computers. This can get very expensive, particularly if there is some distance between the computers.

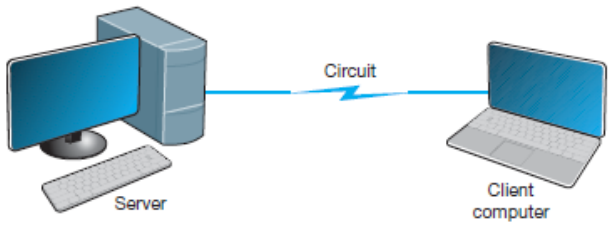


Fig: point to point circuit

Multipoint Circuit

In this configuration, many computers are connected on the same circuit. This means that each must share the circuit with the others. The advantage of multipoint circuits is that they reduce the amount of cable required and typically use the available communication circuit more efficiently. The disadvantage is that only one computer can use the circuit at a time. When one computer is sending or receiving data, all others must wait. It is a time shared connection.

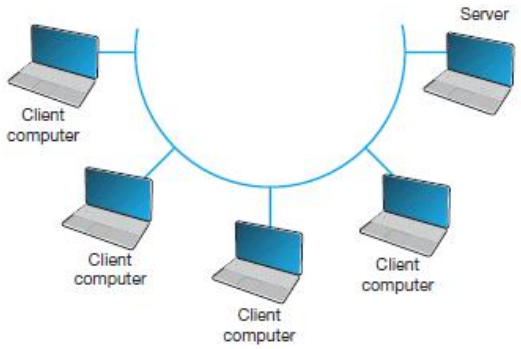


Fig: Multipoint circuit

Data Flow

Circuits can be designed to permit data to flow in one direction or in both directions. Actually, there are three ways to transmit:

i. **Simplex,**
ii. **Half-duplex**
iii. **Full-duplex**

Simplex

It is one way Communication in which sender sends the information and receiver receives it. There no feedback mechanism whether the destination has not the meaning of the data.

E.g. Signal broadcast by radio & TV

Half-Duplex

It is two way communications between transmitter and receiver but only one can send data or receive at a time. When the transmitter transmits the data, the receiver has to wait until the data is sent through that channel and then only receiver can send its data.

E.g. Walkie-talkie, fax machine etc.

Full Duplex

Here the transmission of data possible in two way at a time in the communication process is full duplex.

E.g. Telephone Network, Mobile Communication, Satellite Communication, Computer Data Transmission.

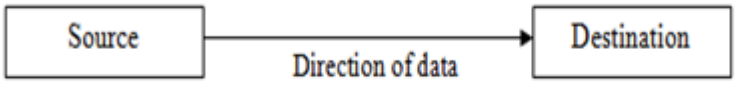


Fig: Simplex Data Communication

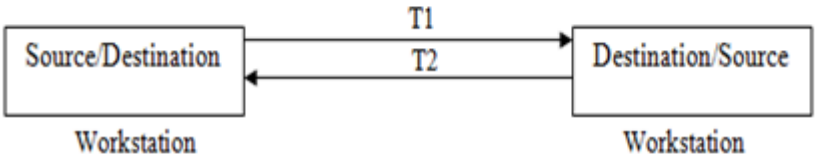


Fig: Half duplex data communication

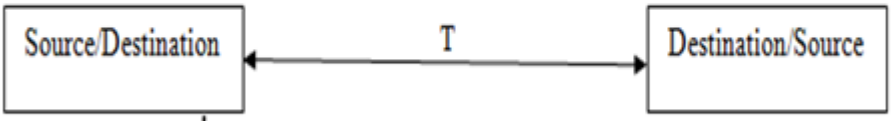


Fig: Full Duplex Data Communication