Chapter No: 1

Introduction to Data Communication

Introduction:

Data is defined as information which is stored in the digital form.

Data communication is the process of transferring digital information between two points.

Data can be alphabets, numeric or symbols and it consists of any one or the combination of the following:

Microprocessor op-codes, control codes, user addresses, program data or data base information.

At the source or destination the data are in digital form but during the transmission it may be analog or digital.

A data communication network can be simply consisting of two computers connected to each other a public telecommunication network.

Data Communications

When we communicate, we are sharing information. This sharing can be local or remote. Between individuals, local communication usually occurs face to face, while remote communication takes place over distance. The term *telecommunication*, which includes telephony, telegraphy, and television, means communication at a distance *(tele* is Greek for "far").

The word ***data*** refers to information presented in whatever form is agreed upon by the parties creating and using the data.

Q. Define data communications.

Data communications are the exchange of data between two devices via some form of transmission medium such as a wire cable. For data communications to occur, the communicating devices must be part of a communication system made up of a combination of hardware (physical equipment) and software (programs).

Q. Describe the characteristics of data communication system.

Characteristics of Data Communication System:

The effectiveness of a data communications system depends on four **fundamental characteristics**: **Delivery**, **Accuracy**, **Timeliness**, and **Jitter**.

1. **Delivery:** The system must deliver data to the **correct destination**. Data must be received by the intended device or user and only by that device or user.

2 **Accuracy:** The system must deliver the **data accurately**. Data that have been altered in transmission and left uncorrected are unusable.

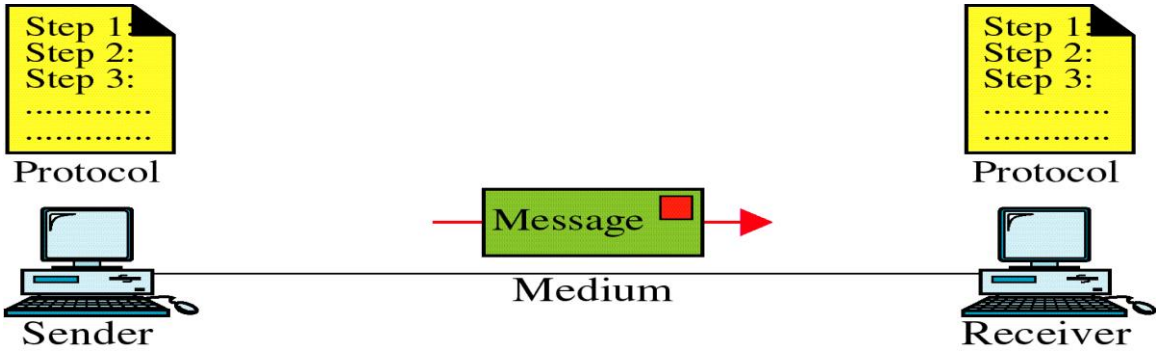
3. **Timeliness:** The system must deliver data in a **timely manner**. Data delivered late are useless. In the case of video and audio, timely delivery means delivering data as they are produced, in the same order that they are produced, and without significant delay. This kind of delivery is called *real-time* transmission.

4. **Jitter:** Jitter refers to the **variation in the packet arrival time**. It is the uneven delay in the delivery of audio or video packets. For example, let us assume that video packets are sent every

3D Ms. If some of the packets arrive with 3D-ms delay and others with 4D-ms delay, an uneven quality in the video is the result.

Q. Draw the components of data communication systems and state the function of each block.

Components of Data Communications System



A data communications system has five components:

1. **Message:** The message is the information (data) to be communicated. Popular forms of information include text, numbers, pictures, audio, and video.

2. **Sender:** The sender is the device that sends the data message. It can be a computer, workstation, telephone handset, video camera, and so on.

3. **Receiver:** The receiver is the device that receives the message. It can be a computer, workstation, telephone handset, television, and so on.

4. **Transmission medium:** The transmission medium is the physical path by which a message travels from sender to receiver. Some examples of transmission media include twisted-pair wire, coaxial cable, fiber-optic cable, and radio waves.

5. **Protocol:** A protocol is a set of rules that govern data communications. It represents an agreement between the communicating devices. Without a protocol, two devices may be connected but not communicating, just as a person speaking French cannot be understood by a person who speaks only Japanese.

Q. Explain Simplex, Half Duplex and Full Duplex communication with examples.

Communication Modes

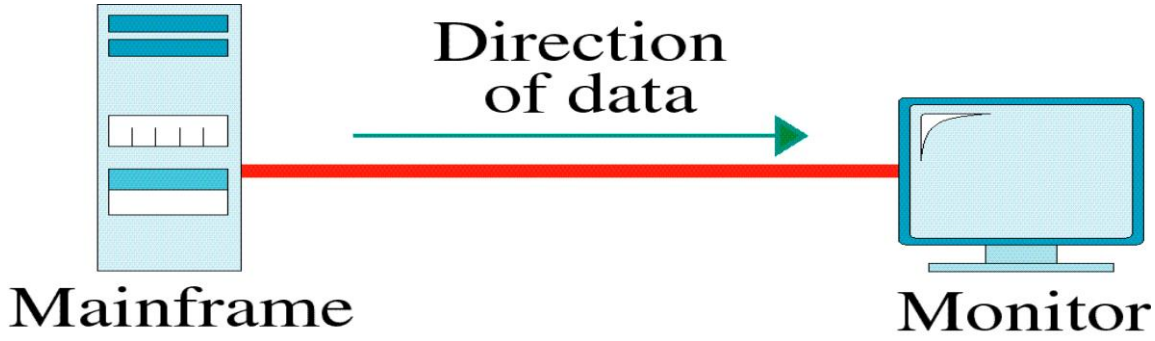
Based on whether the system communicates only in one direction or otherwise, the communication systems are classified as

- Simplex systems
- Half duplex systems
- Full duplex systems

1. Simplex Systems

- In **Simplex** mode, the communication is unidirectional, as on a one-way street.
- Only one of the two devices on a link can transmit; the other can only receive.

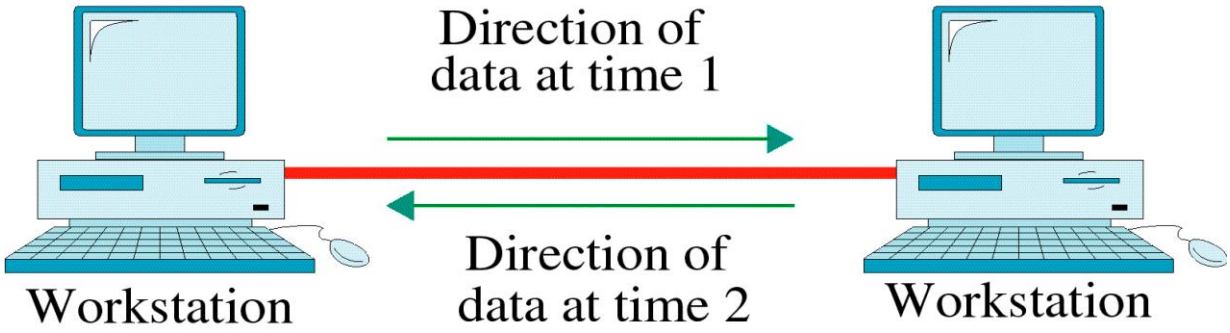
- **Keyboards** and traditional **monitors** are examples of simplex devices. The keyboard can only introduce input; the monitor can only accept output.
- The simplex mode can use the entire capacity of the channel to send data in one direction.



Simplex mode of Communication

2. Half Duplex Systems

- In **Half-duplex** mode, each station can both transmit and receive, but not at the same time. :
- When one device is sending, the other can only receive, and vice versa.
- The half-duplex mode is like a one-lane road with traffic allowed in both directions. When cars are traveling in one direction, cars going the other way must wait. In a half-duplex transmission, the entire capacity of a channel is taken over by whichever of the two devices is transmitting at the time. **Walkie-talkies** and **CB (citizens band) radios** are both half-duplex systems.
- The half-duplex mode is used in cases where there is no need for communication in both directions at the same time; the entire capacity of the channel can be utilized for each direction.



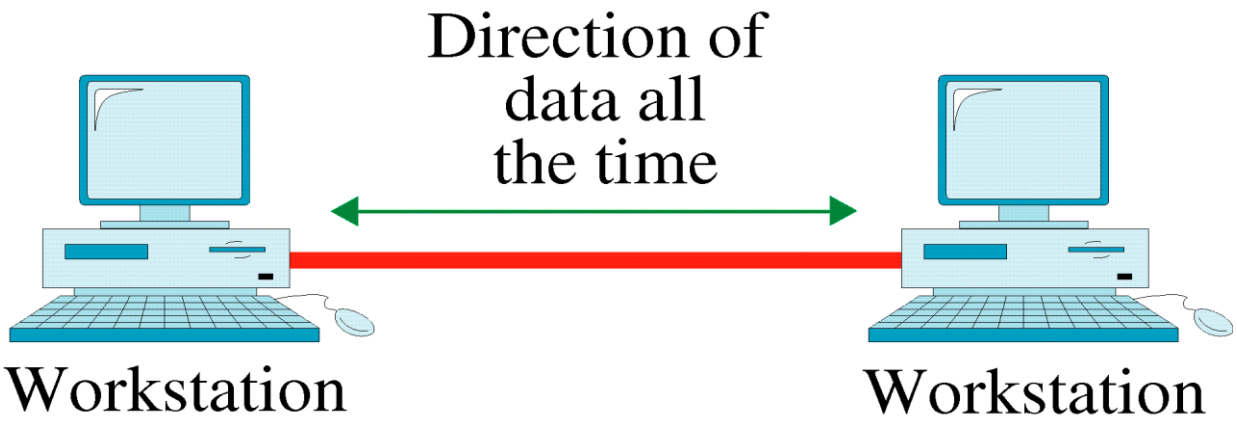
Half Duplex mode of Communication

3. Full-Duplex

- In full-duplex mode (also called duplex), both stations can transmit and receive simultaneously.
- The full-duplex mode is like a two-way street with traffic flowing in both directions at the same time. In full-duplex mode, signals going in one direction share the capacity of the link: with signals going in the other direction. This sharing can occur in two ways: Either the link must contain two physically separate transmission paths, one for sending and the other for

receiving; or the capacity of the channel is divided between signals traveling in both directions.

- One common example of full-duplex communication is the telephone network.
- When two people are communicating by a telephone line, both can talk and listen at the same time. The full-duplex mode is used when communication in both directions is required all the time. The capacity of the channel, however, must be divided between the two directions.



Full Duplex mode of Communication

Q. Define Protocols. Explain key elements of protocols.

Protocol:

- A protocol is a set of rules that govern data communications. A protocol defines what is communicated, how it is communicated, and when it is communicated.
- In computer networks, communication occurs between entities in different systems.
- An entity is anything capable of sending or receiving information. However, two entities cannot simply send bit streams to each other and expect to be understood. For communication to occur, the entities must agree on a protocol.

The key elements of a protocol are: syntax, semantics, and timing.

1) Syntax: (**what is to be communicated?**)

- The term *syntax* refers to the structure or format of the data, meaning the order in which they are presented.
- For example, a simple protocol might expect the first 8 bits of data to be the address of the sender, the second 8 bits to be the address of the receiver, and the rest of the stream to be the message itself.

2) Semantics: (how it is to be communicated)

- The word *semantics* refers to the meaning of each section of bits.
- How is a particular pattern to be interpreted, and what action is to be taken based on that interpretation? For example, does an address identify the route to be taken or the final destination of the message?

3) Timing: (when it should be communicated)

- The term *timing* refers to two characteristics: when data should be sent and how fast they can be sent. For example, if a sender produces data at 100 Mbps but the receiver can process data at only 1 Mbps, the transmission will overload the receiver and some data will be lost.

Q. Define Standard. Name any four Standard Organizations. Give their functions

Standards:

- Standards provide guidelines to manufacturers, vendors, government agencies, and other service providers to ensure the kind of interconnectivity necessary in today's marketplace and in international communications.

- Standards are essential in creating and maintaining an open and competitive market for equipment manufacturers and in guaranteeing national and international interoperability of data and telecommunications technology and processes.

- Data communication standards fall into two categories: *de facto* (meaning "by fact" or "by convention") and *de jure* (meaning "by law" or "by regulation").

1) De facto:

- Standards that have not been approved by an organized body but have been adopted as standards through widespread use are de facto standards.
- De facto standards are often established originally by manufacturers who seek to define the functionality of a new product or technology.

2) **De jure:**

- Those standards that have been legislated by an officially recognized body are de jure standards.

Standards Organizations:

- Standards are developed through the cooperation of standards creation committees, forums, and government regulatory agencies.

Standards Creation Committees:

- While many organizations are dedicated to the establishment of standards, data telecommunications in North America rely primarily on those published by the following:

1) International Organization for Standardization

- **(ISO):** The ISO is a multinational body whose membership is drawn mainly from the standards creation committees of various governments throughout the world.
- The ISO is active in developing cooperation in the realms of scientific, technological, and economic activity.

2) International Telecommunication Union-Telecommunication Standards Sector (ITU-T):

- By the early 1970s, a number of countries were defining national standards for telecommunications, but there was still little international compatibility.
- The United Nations responded by forming, as part of its International Telecommunication Union (ITU), a committee, the Consultative Committee for International Telegraphy and Telephony (CCITT).
- This committee was devoted to the research and establishment of standards for telecommunications in general and for phone and data systems in particular. On March 1, 1993, the name of this committee was changed to the International Telecommunication Union - Telecommunication Standards Sector (ITU-T).

3) American National Standards Institute (ANSI):

- The American National Standards Institute is a completely private, nonprofit corporation not affiliated with the U.S. federal government. However, all ANSI activities are undertaken with the welfare of the United States and its citizens occupying primary importance.

4) Institute of Electrical and Electronics Engineers (IEEE):

- The Institute of Electrical and Electronics Engineers is the largest professional engineering society in the world.
- International in scope, it aims to advance theory, creativity, and product quality in the fields of electrical engineering, electronics, and radio as well as in all related branches of engineering.
- As one of its goals, the IEEE oversees the development and adoption of international standards for computing and communications.

5) Electronic Industries Association (EIA):

- The Electronic Industries Association is a nonprofit organization devoted to the promotion of electronics manufacturing concerns.
- Its activities include public awareness education and lobbying efforts in addition to standards development.
- In the field of information technology, the EIA has made significant contributions by defining physical connection interfaces and electronic signaling specifications for data communication.

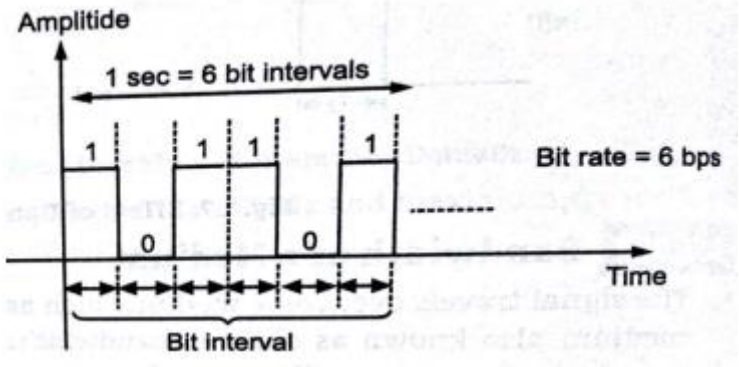
Bandwidth, Data Transmission Rate, Baud Rate and Bits Per Second

Bandwidth is measured as the amount of data that can be transferred from one point to another within a network in a specific amount of time. Typically, bandwidth is expressed as a bitrate and measured in bits per second (bps).

The term bandwidth refers to the transmission capacity of a connection and is an important factor when determining the quality and speed of a network or the internet connection.

Definition of Bit Rate

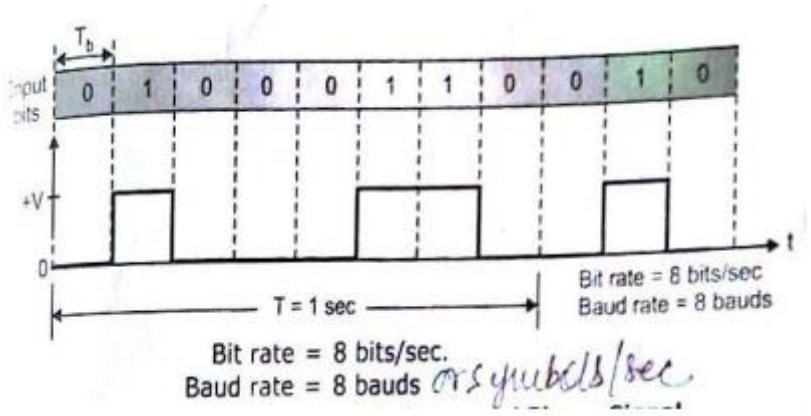
Bit rate can be defined as the number of bit intervals per second. And bit interval is referred to as the time needed to transfer one single bit. In simpler words, the bit rate is the number of bits sent in one second, usually expressed in bits per second (bps). For example, kilobits per second (Kbps), Megabits per second (Mbps), Gigabits per second (Gbps), etc.



Definition of Baud Rate

Baud rate is defined as the number of signal units per second. It is always less than or equal to bit rate. It is represented as bauds or symbols/second.

Baud rate is expressed in the number of times a signal can change on transmission line per second. Usually, the transmission line uses only two signal states, and make the baud rate equal to the number of bits per second that can be transferred.



An example can illustrate it. For example, 1500 baud rate illustrates that the channel state can alter up to 1500 times per second. The meaning of changing state means that channel can change its state from 0 to 1 or from 1 to 0 up to 1500 times per second (in the given case).

- bit: a unit of information
- baud: a unit of signaling speed.
- Bit rate:b
  - Number of bits transmitted per second.
- Baud Rate:s
  - Number of symbols transmitted per second.
- General formula:
  - **b=s*n**
  - Where n is number of bits per symbol.

Key Differences Between Bit Rate and Baud Rate

1. Bit rate is the number bits (0's and 1's) transmitted per second.
   On the other hand Baud rate is the number of times a signal is traveling comprised of bits.

2. Baud rate can determine the **bandwidth** of the channel or its required amount to send the signal while through Bit rate it is not possible.Bit Rate can be expressed by the given equation:
   Bit rate = baud rate x the number of bits per signal unit
   In contrary Baud rate is expressed in the given equation:
   Baud rate = bit rate / the number of bits per signal unit

Question: Calculate the baud rate for the given bit rate and type of modulation:
(i) 5000 bps, ASK (ii) 4000 bps, FSK
Answer:

For baud rate (S), we know that the formula is:
S=N/r.
N = S * r
Here, N is Bit rate, S is the Baud rate
r = number of bits in signal elements
So, at first we need to calculate r for each case.
We know, $r = \log_2 L$.

i)For ASK, $r = \log_2 2 = 1$
S=5000 bps/1=5000 baud
ii) For FSK, $r = \log_2 2 = 1$
S=4000bps/1=4000 baud

Question: A signal carries five bits in each signal element. If 1600 signal elements are sent per second, find the baud rate and bit rate in kbps.
Answer:

Baud rate is number of signal elements per second.
Bit rate is the number of bits per second.
We also know that S=N/r where S is the baud rate, N is the bit rate and r is the bits in each signal element.
In this case 1600 signal elements are sent per second.
So baud rate is 1600.
Now S=1600,r=5 and N is unknown.
So N=S*r=1600*5=8000 bps or 8 kbps.
Therefore the bit rate is 8kbps

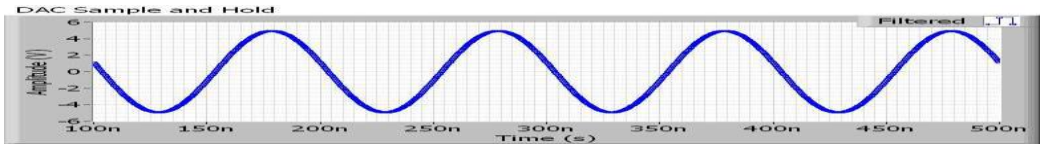
BASIS FOR COMPARISON	BIT RATE	BAUD RATE
Basic	Bit rate is the count of bits per second.	Baud rate is the count of signal units per second.
Meaning	It determines the number of bits traveled per second.	It determines how many times the state of a signal is changing.
Term usually used	While the emphasis is on computer efficiency.	While data transmission over the channel is more concerned.
Bandwidth determination	Can not determine the bandwidth.	It can determine how much bandwidth is required to send the signal.
Equation	Bit rate = baud rate x the count of bits per signal unit	Baud rate = bit rate / the number of bits per signal unit

Analog Signal and Digital Signal

Analog Signal

An **analog signal** is a continuous wave denoted by a sine wave (pictured below) and may vary in signal strength (amplitude) or frequency (waves per unit time). The sine wave's amplitude value can be seen as the higher and lower points of the wave, while the frequency value is measured in the sine wave's physical length from left to right.

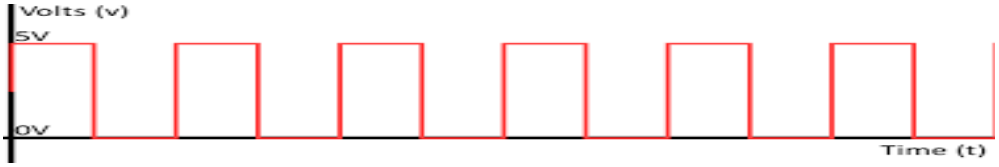
There are many examples of analog signals around us. The sound from a human voice is analog, because sound waves are continuous, as is our own vision, because we see various shapes and colors in a continuous manner due to light waves. Even a typical kitchen clock having its hands moving continuously can be represented as an analog signal.



Digital Signal

A **digital signal** - a must for computer processing - is described as using binary (0s and 1s), and therefore, cannot take on any fractional values. As illustrated in the graphic below, digital

signals retain a uniform structure, providing a constant and consistent signal. Because of the inherent reliability of the digital signal, technology using it is rapidly replacing a large percentage of analog applications and devices. For example, the wristwatch, showing the time of day, with its minute, hour, and sweeping second hands, is being replaced by the digital watch, which offers the time of day and other information using a numerical display. A typical digital signal is represented below. Note the equally dispersed 1s and 0s.



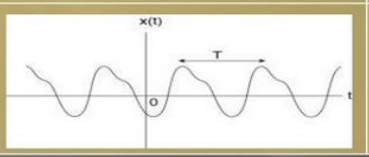
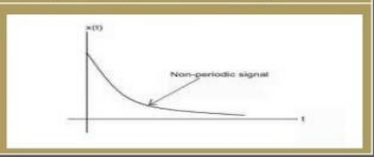
Analog Signal	Digital Signal
An analog signal signifies a continuous signal that keeps changes with a time period.	A digital signal signifies a discrete signal that carries binary data and has discrete values.
Analog signals are continuous sine waves	Digital signal is square waves.
Analog signals describe the behavior of the wave with respect to amplitude, time period, & phase of the signal.	Digital signals describe the behavior of the signal with respect to the rate of a bit as well as bit interval.
Analog signal range will not be set.	Digital signal is limited as well as ranges from 0 to 1.
Analog signal is further horizontal toward distortion during the response to noise	A digital signal has resistance in response toward the noise, therefore, it does not often face distortion.
An analog signal broadcasts the information in the signal form.	A digital signal broadcasts the information in the form of binary that is bits.
The example of an analog signal is the human voice	The example of a digital signal is the data transmission in a computer.

Periodic and Non-periodic signals

- A signal is periodic signal if it completes a pattern within measurable time frame.
- A periodic signal is characterised by **amplitude, frequency and phase.**
- Mathematically: $v(t)=V \sin(2\pi ft+\theta)$
  - V:Peak Amplitude
  - F:frequency
  - t:Time(seconds)
  - θ:Phase(degree or radians)
- **Amplitude** is the highest height of the signal, maximum value or strength of the signal over time; typically, this value is measured in volts.
- **frequency** is the rate [in cycles per second, or Hertz (Hz)] at which the signal repeats., and
- **Phase** is a measure of the relative position in time within a single period of a signal
- An analog signal is not resistant toward the noise, therefore; it faces distortion as well as reduces the transmission quality.

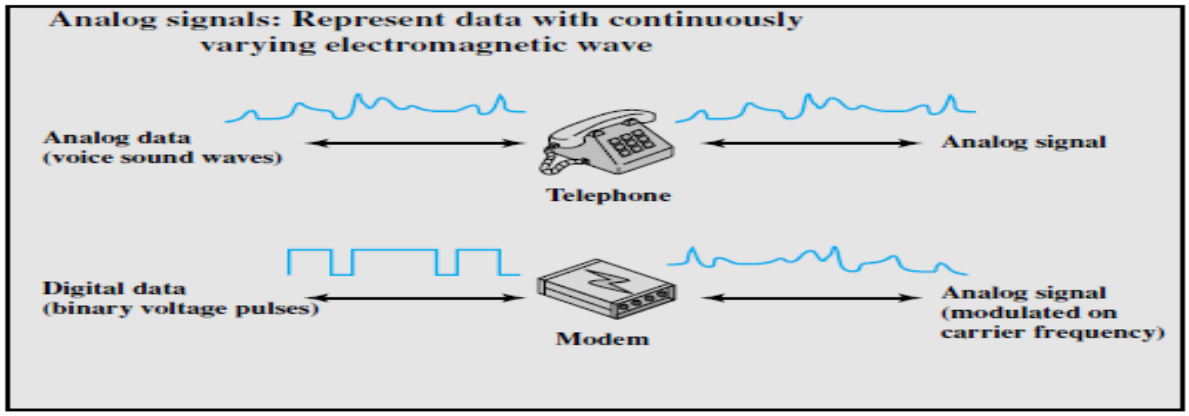
Non-periodic signals

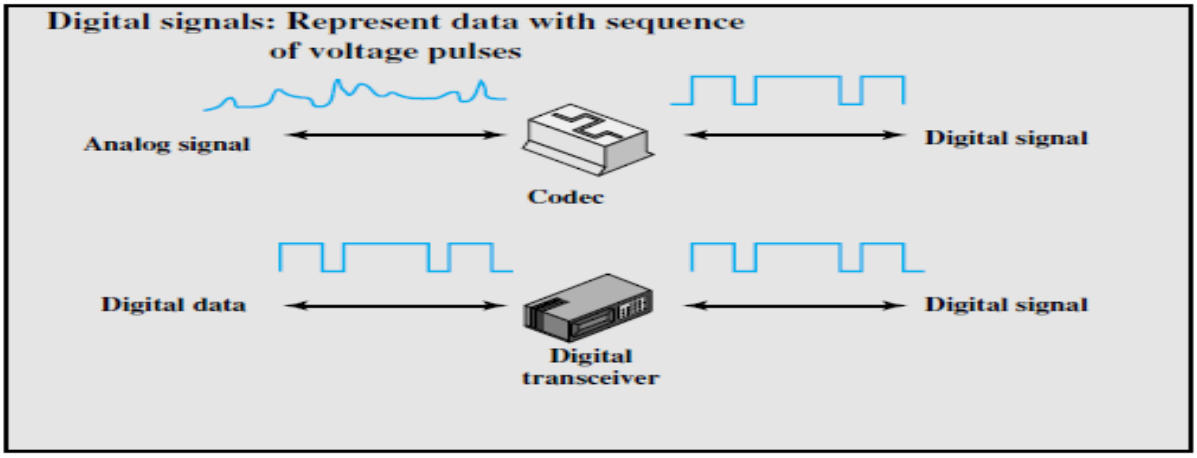
- A signal that does not repeats its pattern over a period is called aperiodic signal or non periodic.
- Both the Analog and Digital can be periodic or aperiodic: but in data communication **periodic analog signals and aperiodic digital** signals are used.

Periodic Signal	Aperiodic Signal
❑ A signal which repeats itself after a specific interval of time is called periodic signal.	❑ A signal which does not repeat itself after a specific interval of time is called aperiodic signal.
❑ A signal that repeats its pattern over a period is called periodic signal	❑ A signal that does not repeats its pattern over a period is called aperiodic signal or non periodic.
❑ They can be represented by a mathematical equation	❑ They cannot be represented by any mathematical equation
❑ Their value can be determined at any point of time	❑ Their value cannot be determined with certainty at any given point of time
❑ They are deterministic signals	❑ They are random signals
❑ Example: sine cosine square sawtooth etc	❑ Example: sound signals from radio , all types of noise signals
❑ Figure: 	❑ Figure: 

Analog and Digital data

- Analog data take on continuous values in time interval.
- For example, voice and video are continuously varying patterns of intensity. Most data collected by sensors, such as temperature and pressure, are continuous valued.
- The most familiar example of analog data is **audio**, which, in the form of acoustic sound waves, can be perceived directly by human beings.
- Digital data take on discrete values; examples are **text and integers**.
- They cannot be easily stored or transmitted by data processing and communications systems in character form.
- Morse code, **International Reference Alphabet (IRA)** are used to translate text into binary.





Analog transmission

- **Analog transmission** is a means of transmitting analog signals without regard to their content; the signals may represent analog data (e.g., voice) or digital data.
- In either case, the analog signal will become weaker (attenuate) after a certain distance.
- To achieve longer distances, the analog transmission system includes amplifiers that boost the energy in the signal.
- Unfortunately, the amplifier also boosts the noise components.

Digital transmission

- **Digital transmission**, in contrast, assumes a binary content to the signal.
- A digital signal can be transmitted only a limited distance before attenuation.
- To achieve greater distances, repeaters are used. A repeater receives the digital signal, recovers the pattern of 1s and 0s, and retransmits a new signal. Thus the attenuation is overcome.

(a) Data and Signals

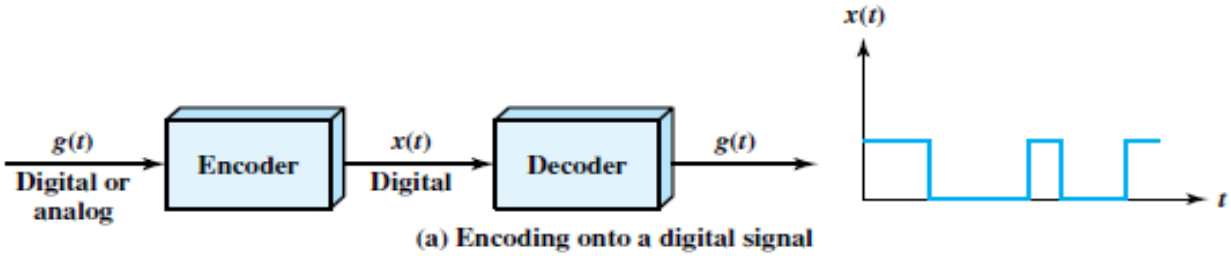
	Analog Signal	Digital Signal
Analog Data	Two alternatives: (1) signal occupies the same spectrum as the analog data; (2) analog data are encoded to occupy a different portion of spectrum.	Analog data are encoded using a codec to produce a digital bit stream.
Digital Data	Digital data are encoded using a modem to produce analog signal.	Two alternatives: (1) signal consists of two voltage levels to represent the two binary values; (2) digital data are encoded to produce a digital signal with desir ed properties.

Both analog and digital information can be encoded as either analog or digital signals. The particular encoding that is chosen depends on the specific requirements to be met and **the media and communications facilities** available.

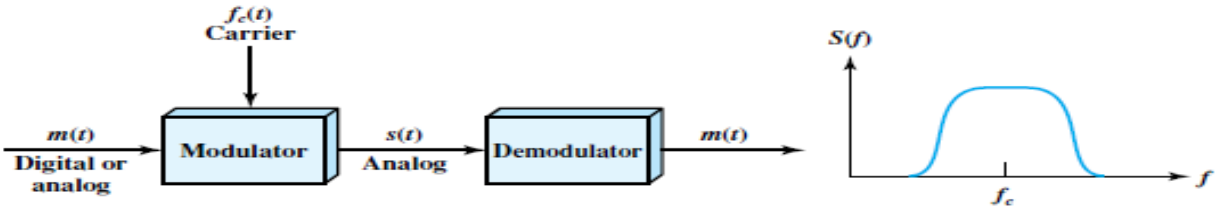
1. **Digital data, digital signals(Digital data Transmission):**
    - The simplest form of digital encoding of digital data is to assign one voltage level to binary one and another to binary zero.
    - More complex encoding schemes are used to improve performance, by altering the spectrum of the signal.
2. **Digital data, analog signal:**
    - A modem converts digital data to an analog signal so that it can be transmitted over an analog line.

- The basic techniques are **amplitude shift keying (ASK), frequency shift keying (FSK), and phase shift keying (PSK)**.
- All involve altering one or more characteristics of a carrier frequency to represent binary data.

3. **Analog data, digital signals:**
   - Analog data, such as voice and video, are often digitized to be able to use digital transmission facilities.
   - The simplest technique is **pulse code modulation (PCM)**, which involves sampling the analog data.
4. **Analog data, analog signals:**
   - Analog data are modulated by a carrier frequency to produce an analog signal, which can be utilized on an analog transmission system.
   - The basic techniques are **amplitude modulation (AM), frequency modulation(FM), and phase modulation (PM).**



(a) Encoding onto a digital signal



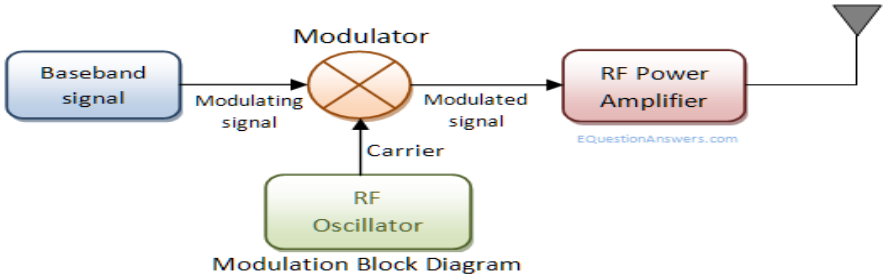
(b) Modulation onto an analog signal

- ## Modulation:

Now we have to develop some way to send the information of message signal via this carrier signal. The carrier signal is a high frequency sinusoidal signal represented by amplitude, frequency and phase. We can vary one of this parameter accordingly with the message information.

- ## What is Modulation?

Modulation is an operation of varying amplitude or frequency or phase of carrier signal according to the instantaneous amplitude of the baseband signal/modulating signal.



Modulation Block Diagram

Here baseband signals comes from a audio/video or computer. Baseband signals are also called modulating signal as it modulates carrir signal. Carrier signals are high frequecy radio waves it generally comes from a radio frequency oscillators. These two signls are combined in modulator. Modulator takes the instantenious amplitute of baseband signal and varies amplitute/frequency/phase of carrier signal. Resultant signal is a modulated signal. It goes to an RF-amplifier for signal power boosting and then feed to antenna or a co-axial cable.

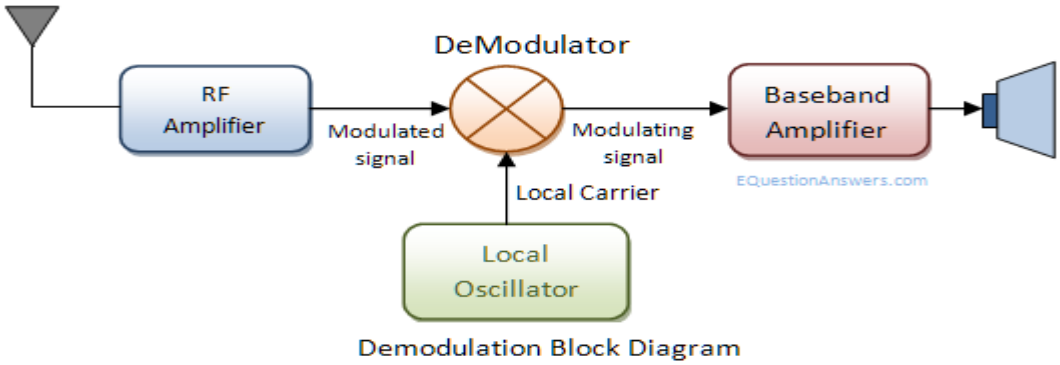
There are two types of modulation analog and digital. Analog modulation delas with the voice, video and regular waves of base band signals. Where as digital modulations are with bit streams or symbols from computing vevices as base band signals.

- ## DeModulation:

Demodulation is the opposite process of modulation. Modulator is a part of signal transmitter where as demodulator is the receiving side. In broadcast system radio transmitting station does to modulation part. A radio receiver acts as a demodulator. A modem receives signals and also transmits signals thus it does modulation and demodulation at the same time. Thus the name modem has been given. A radio antenna receives low power signal. A co-axial cable end point can also take as an signal input. An RF amplifier boosts the signal amplitude. Then the signal goes to a demodulator. demodulator does the reverse of modulation and extracts the backband signal from carrier. Then the base band signal is amplified to feed a audio speaker or video monitor or TTL/CMOS signal levels to match computer inputs.

- ## What is De-modulation?

Demodulation is the opposite process of modulation where the varying amplitude, frequency or phase of carrier signal is extracted to construct the original the message signal.



Demodulation Block Diagram

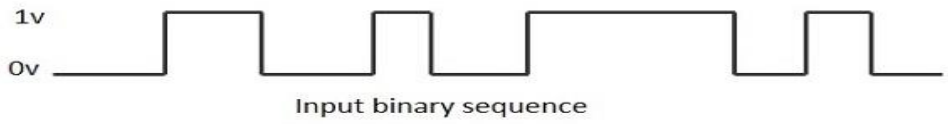
Digital to Analog conversion

- The case of transmitting digital data using analog signals.
- The most familiar use is for transmitting digital data through the public telephone network.
- The telephone network was designed to receive, switch, and transmit analog signals in the voice-frequency range of about 300 to 3400 Hz.
- It is not at present suitable for handling digital signals from the subscriber locations.
- Thus digital devices are attached to the network via a **modem (modulator-demodulator)**, which converts digital data to analog signals, and vice versa.
- Modulation involves operation on one or more of the three characteristics of a carrier signal: **amplitude, frequency, and phase.**
- Accordingly, there are three basic encoding or modulation techniques for transforming digital data into analog signals:
    - Amplitude Shift Keying (ASK),
    - Frequency Shift Keying (FSK), and
    - Phase Shift Keying (PSK).

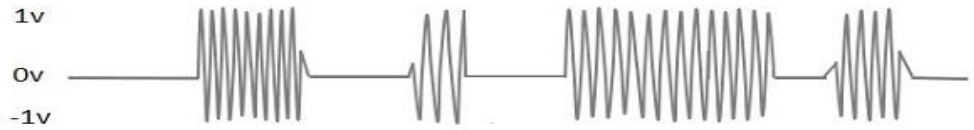
1. Amplitude Shift Keying (ASK)

- ASK is the digital carrier Modulation in which amplitude of carrier will take one of the two values in response to 0 or 1 value of digital data.

- **Amplitude Shift Keying (ASK)** is a type of Amplitude Modulation which represents the binary data in the form of variations in the amplitude of a signal.
- Any modulated signal has a high frequency carrier. The binary signal when ASK modulated, gives a **zero** value for **Low** input while it gives the **carrier output** for **High** input.
- The following figure represents ASK modulated waveform along with its input.



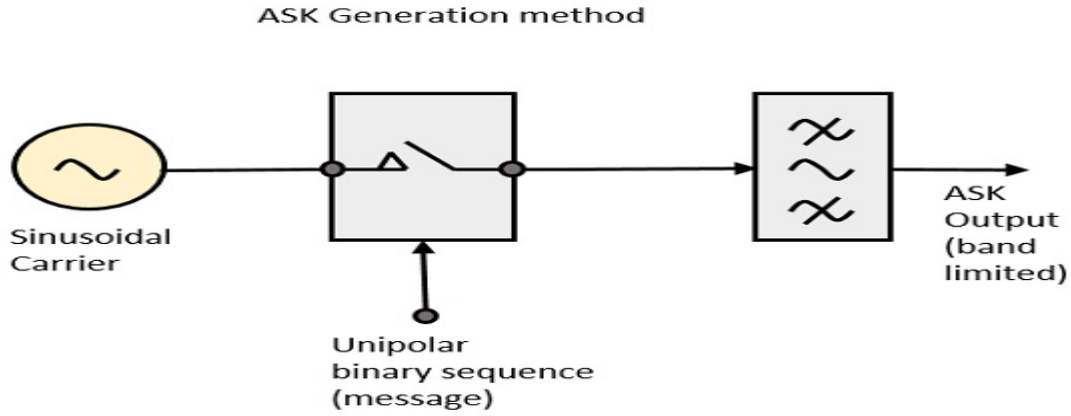
Input binary sequence



ASK Modulated output wave

ASK Modulator

The ASK modulator block diagram comprises of the carrier signal generator, the binary sequence from the message signal and the band-limited filter. Following is the block diagram of the ASK Modulator.

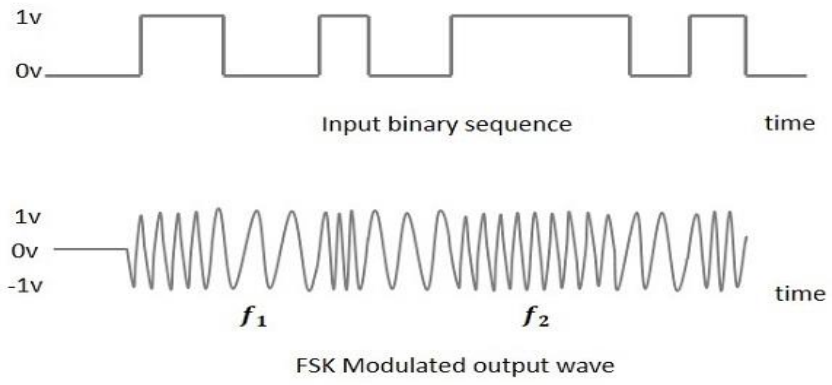


Application:

1. Used in our infrared remote controls
2. Used in fibre optical tranmitter and receiver.

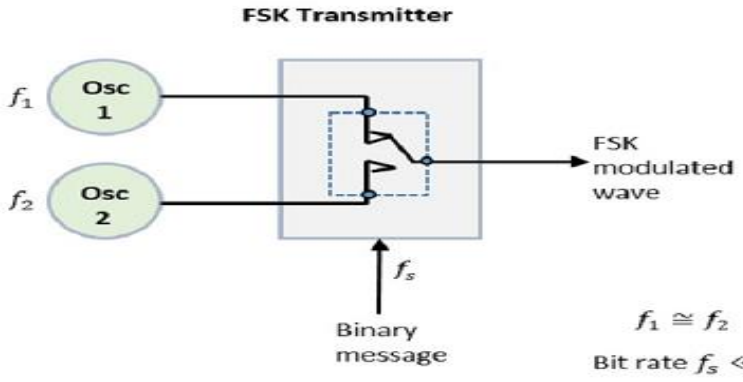
2. Frequency Shift Keying (FSK)

- **Frequency Shift Keying (FSK)** is the digital modulation technique in which the frequency of the carrier signal varies according to the digital signal changes. FSK is a scheme of frequency modulation.
- The output of a FSK modulated wave is high in frequency for a binary High input and is low in frequency for a binary Low input. The binary **1s** and **0s** are called Mark and Space frequencies.
- The following image is the diagrammatic representation of FSK modulated waveform along with its input.



FSK Modulator

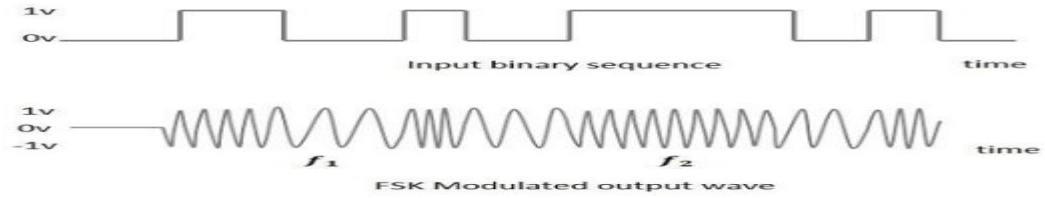
The FSK modulator block diagram comprises of two oscillators with a clock and the input binary sequence. Following is its block diagram.



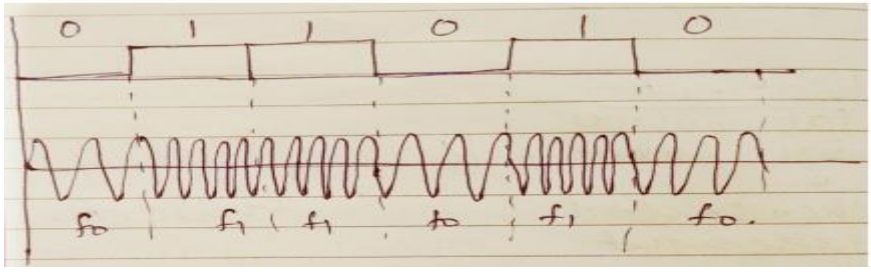
The two oscillators, producing a higher and a lower frequency signals, are connected to a switch along with an internal clock. To avoid the abrupt phase discontinuities of the output waveform during the transmission of the message, a clock is applied to both the oscillators, internally. The binary input sequence is applied to the transmitter so as to choose the frequencies according to the binary input.

Question: Explain the process of FSK modulation with diagram. (4Marks)
Answer: In FSK, frequency of sinusoidal carrier is shifted between two discrete values. One of these frequencies (f_1) represents a binary 1 and other value (f_2) represents binary 0.There is no change in amplitude of carrier. It consists of voltage controlled oscillators (VCO) which produce sine waves at frequencies f_1 and f_0. Corresponding to "binary 0 "input, the VCO

produces a sinewave of frequency f_0 whereas corresponding to binary 1 input VCO produces a sinewave of frequency f_1.



Question: Draw a BFSK waveform to represent the following bit stream 0 11 0 1 0.



Application:

1. Many modems used FSK in telemetry systems

3. Phase Shift Keying (PSK)

Phase Shift Keying (PSK) is the digital modulation technique in which the phase of the carrier signal is changed by varying the sine and cosine inputs at a particular time. PSK technique is widely used for wireless LANs, bio-metric, contactless operations, along with RFID and Bluetooth communications.

PSK is of two types, depending upon the phases the signal gets shifted. They are −

Binary Phase Shift Keying (BPSK)

This is also called as 2-phase PSK or Phase Reversal Keying. In this technique, the sine wave carrier takes two phase reversals such as 0° and 180°.

BPSK is basically a Double Side Band Suppressed Carrier (DSBSC) modulation scheme, for message being the digital information.

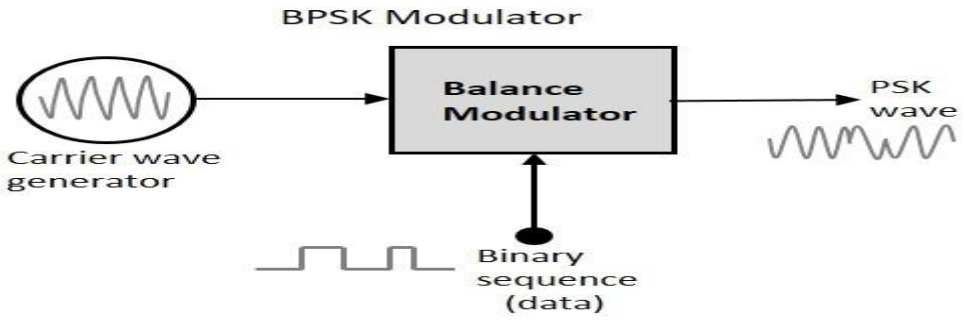
Quadrature Phase Shift Keying (QPSK)

This is the phase shift keying technique, in which the sine wave carrier takes four phase reversals such as 0°, 90°, 180°, and 270°.

If this kind of techniques are further extended, PSK can be done by eight or sixteen values also, depending upon the requirement.

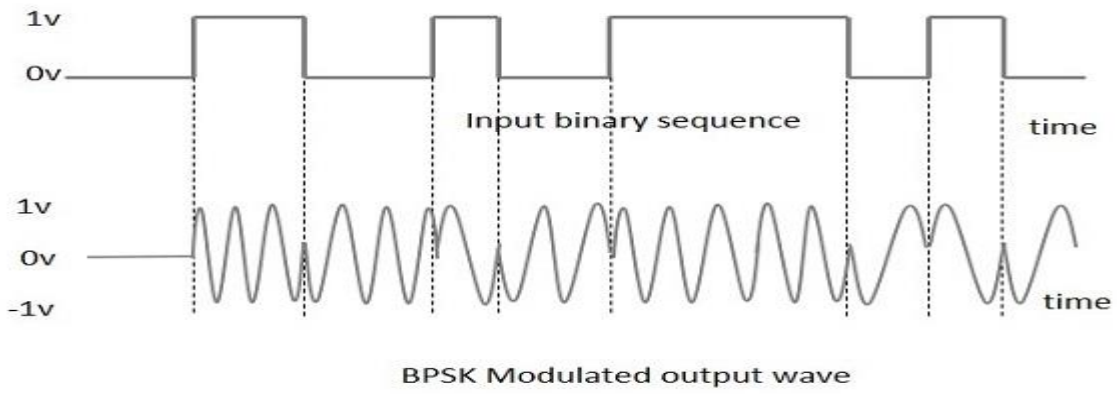
BPSK Modulator

The block diagram of Binary Phase Shift Keying consists of the balance modulator which has the carrier sine wave as one input and the binary sequence as the other input. Following is the diagrammatic representation.



The modulation of BPSK is done using a balance modulator, which multiplies the two signals applied at the input. For a zero binary input, the phase will be **0°** and for a high input, the phase reversal is of **180°**.

Following is the diagrammatic representation of BPSK Modulated output wave along with its given input.

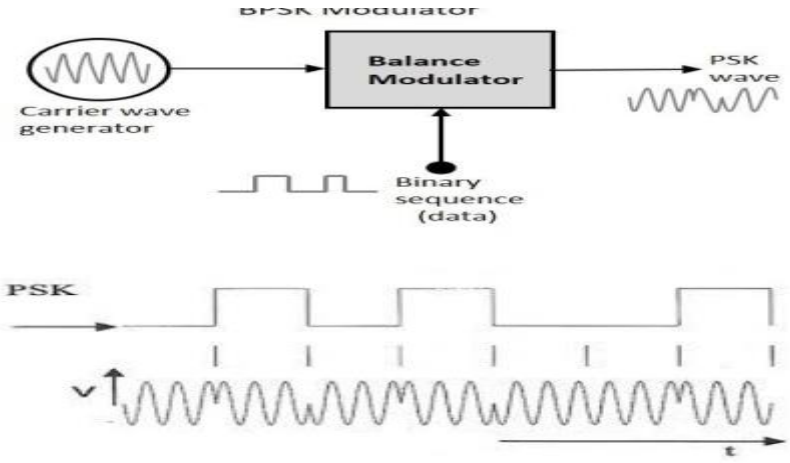


BPSK Modulated output wave

The output sine wave of the modulator will be the direct input carrier or the inverted (180° phase shifted) input carrier, which is a function of the data signal.

Question: Explain process of phase shift keying.(4 Marks)

Answer: Phase-shift keying (PSK) is a digital to analog modulation scheme based on changing, or modulating, the initial phase of a carrier signal. PSK is used to represent digital information, such as binary digits zero (0) and one (1).The modulation of PSK is done using a balance modulator, which multiplies the two signals applied at the input. For a zero binary input, the phase will be 180° and for a high input, the phase reversal is of 0°. Following is the diagrammatic representation of PSK Modulated output wave along with its given input.



The output sine wave of the modulator will be the direct input carrier or the inverted (180° phase shifted) input carrier, which is a function of the data signal. Amplitude and frequency of the original carrier signal is kept constant.

Application:

1. Used in our ADSL broadband modem
2. Used in satellite communication
3. Used in our mobile phones

Comparison of ASK, FSK and PSK

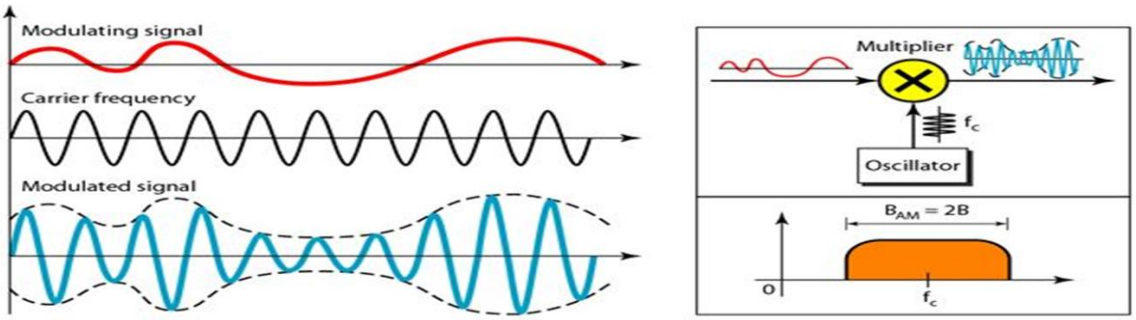
Parameters	ASK	FSK	PSK
Variable characteristics	Amplitude	Frequency	Phase
Bandwidth	Is proportional to signal rate (B =(1+d)S),d is due to modulation & filtering ,lies between 0 & 1.	B=(1+d)×S+2Δf	B=(1+d)×S
Noise immunity	low	High	High
Complexity	Simple	Moderately complex	Very complex
Error probability	High	Low	Low
Performance in presence of noise	Poor	Better than ASK	Better than FSK
Bit rate	Suitable upto 100 bits/sec	Suitable upto about 1200 bits/sec	Suitable for high bit rates

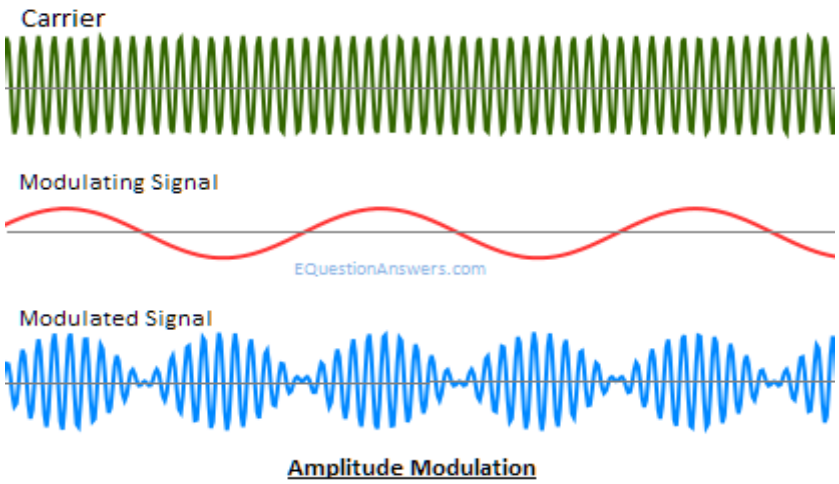
- ## Analog to Analog Conversion

  - Analog-to-analog conversion, or modulation, is the representation of analog information by an analog signal.
  - It is a process by which a characteristic of carrier wave is varied according to the instantaneous amplitude of the modulating signal.
  - Analog to Analog conversion can be done in three ways:
    - **Amplitude Modulation**
    - **Frequency Modulation**
    - **Phase Modulation**

1. AMPLITUDE MODULATION:

- The modulation in which the **amplitude** of the carrier wave is varied according to the instantaneous amplitude of the modulating signal keeping **phase and frequency** as constant.
- AM is normally implemented by using a simple multiplier because the amplitude of the carrier signal needs to be changed according to the amplitude of the modulating signal.
- **AM bandwidth:**
  The modulation creates a bandwidth that is twice the bandwidth of the modulating signal and covers a range centered on the carrier frequency.
  Bandwidth= 2fm





Amplitude Modulation

- ## AM Advantage

  - AM is the simplest type of modulation. Hardware design of both transmitter and receiver is very simple and less cost effective.

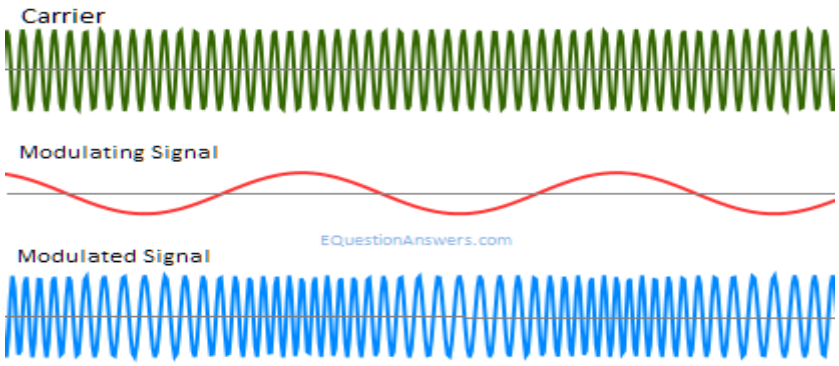
- ## AM Disadvange:

  - AM is very susceptible to noise.

- **Application:**
  - AM radio broad cast is an example

2. Frequency modulation

FM or Frequency modulation is the process of varying the in instantaneous frequency of Carrier signal accordingly with instantaneous amplitude of message signal.



Frequency Modulation

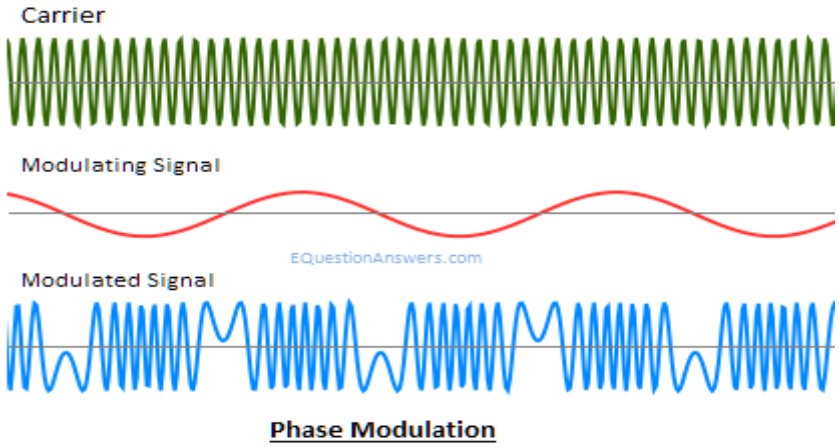
- **FM Advantage**
  - Modulation and demodulation does not catch any channel noise.
- **FM Disadvange:**
  - Circuit needed for FM modulation and demodulation is bit complicated than AM
- **Application:**
  - FM radio broad cast is an example

Question: Compare amplitude modulation and frequency modulation (4 points).
Answer:

Parameter	Amplitude modulation (AM)	Frequency modulation (FM)
Definition	Amplitude modulation (AM) is the process of changing the amplitude of a high frequency carrier signal in proportion with the instantaneous value of the modulating signal keeping frequency &Phase constant.	Frequency modulation (FM) is the process of changing the frequency of carrier signal in proportion with the instantaneous value of the modulating signal keeping Amplitude &Phase constant.
Waveform	AM wave: 	FM wave: 
Bandwidth	BW= $2f_m$(f_m -frequency of modulating signal)	Bandwidth =2 [$\delta + f_m$] (f_m - frequency of modulating signal)
Noise immunity	Less	More
Modulation index	$m_a = \frac{V_m}{V_c}$ V_m - Amplitude of modulating signal V_c- Amplitude of carrier signal	$m_f = \frac{\delta}{f_m}$ δ – frequency deviation f_m - frequency of modulating signal
Frequencies used for transmission	535 – 1700 KHz	88.1 – 108.1 MHz

3. Phase modulation (PM)

PM or Phase modulation is the process of varying the instantaneous phase of Carrier signal accordingly with instantaneous amplitude of message signal.



Phase Modulation

- **PM Advantage**
  - Modulation and demodulation does not catch any channel noise.
- **PM Disadvange:**
  - Circuit needed for PM modulation and demodulation is bit complicated than AM and FM
- **Application:**
  - Satellite communication.