Data Communication & Networks

Unit 1

Introduction

What we study in this course?

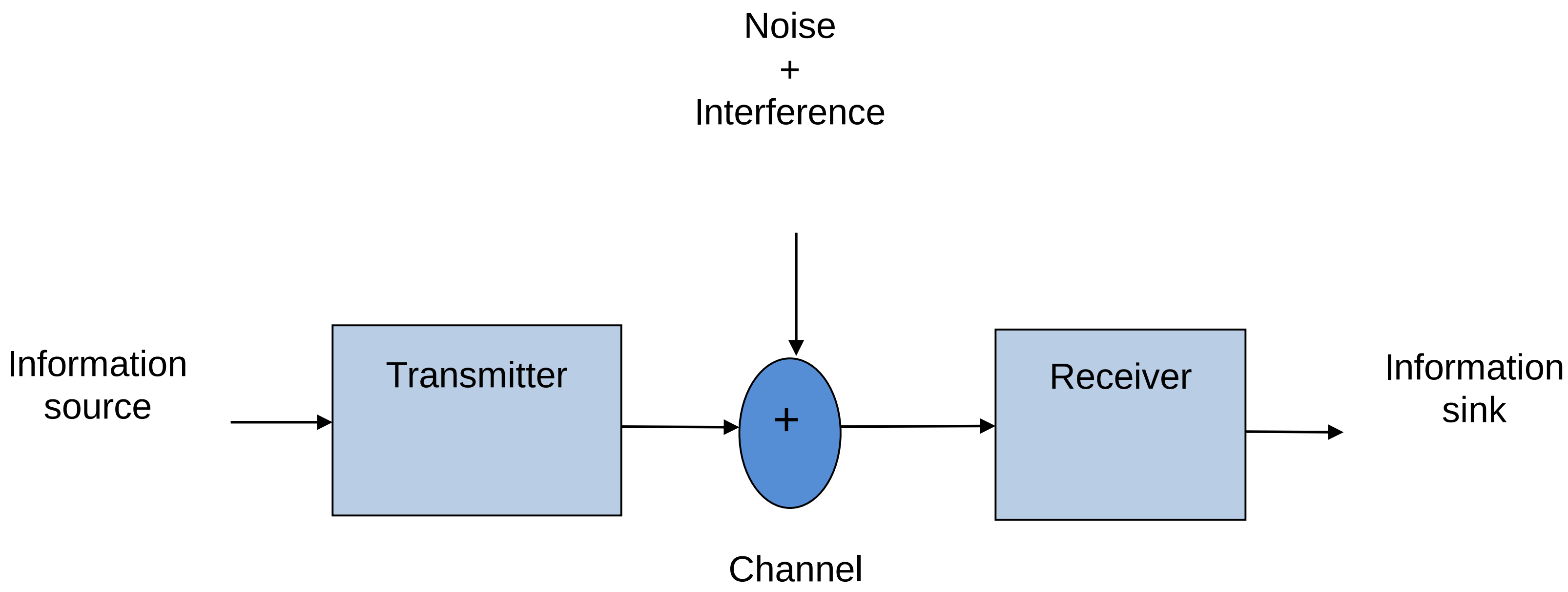
- Introduction to communication systems
- Signals and analysis and transmission of signals
- Amplitude Modulation
- Angle Modulation
- Noise
- Receivers
- Recent Trends and Development in Analog Communication

Text Books

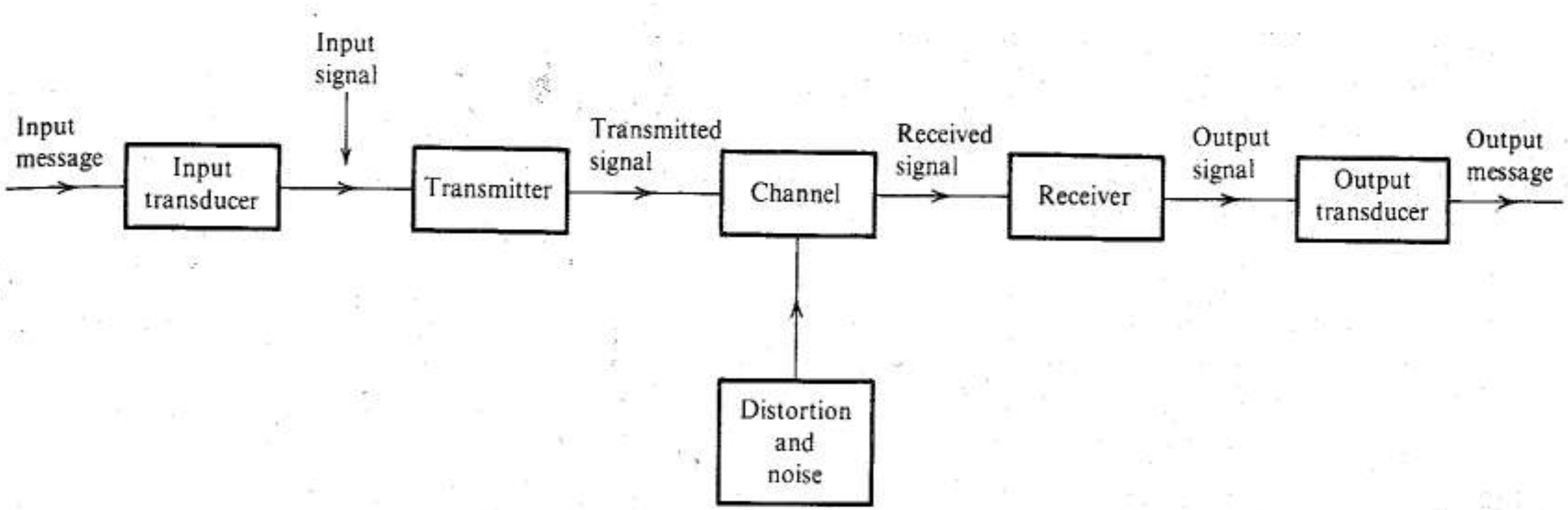
- **“Modern digital and analog Communication systems“, B. P. Lathi, Oxford, University Press., 4th Ed, 2010.**

- **“Electronic Communications”, Dennis Roddy and John Coolen, Pearson, 4th edition, 2011.**

Communication system

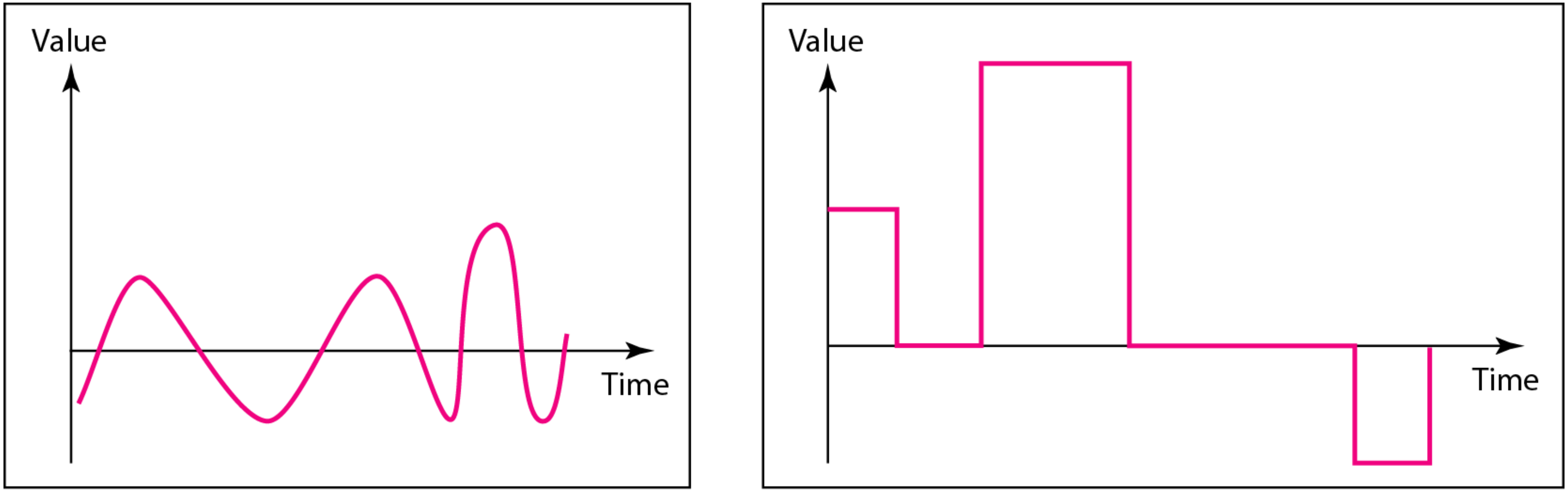


Detailed Block Diagram



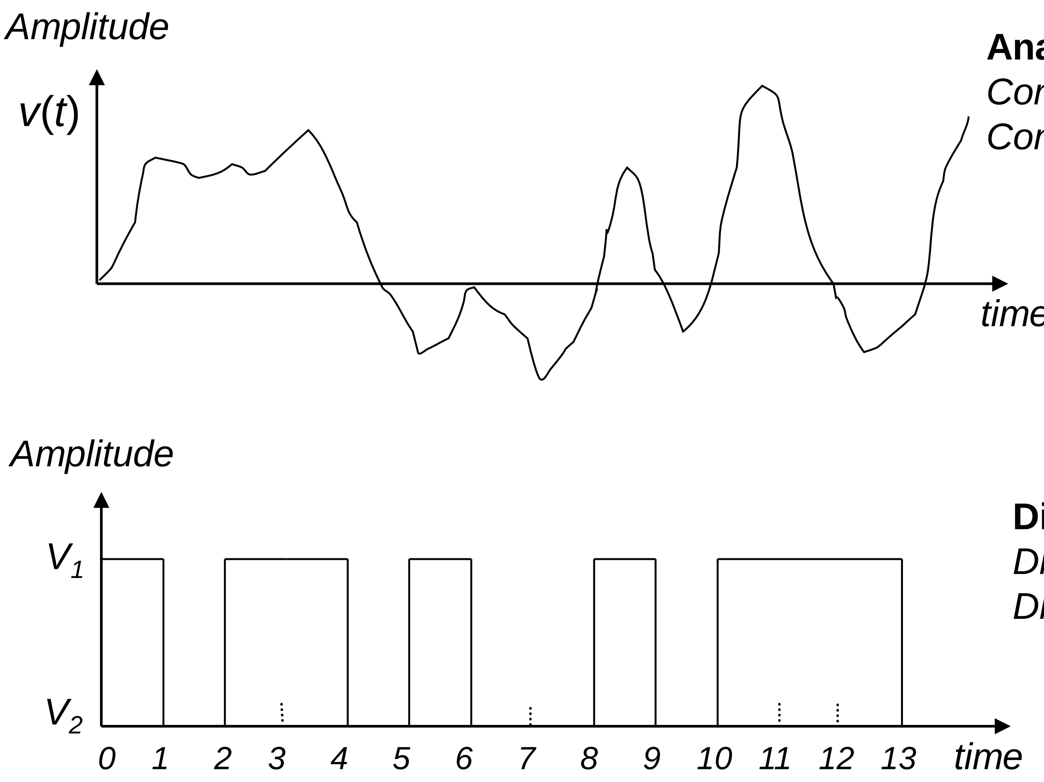
Analog and Digital

- Data can be analog or digital. The term analog data refers to information that is continuous; digital data refers to information that has



a. Analog signal b. Digital signal

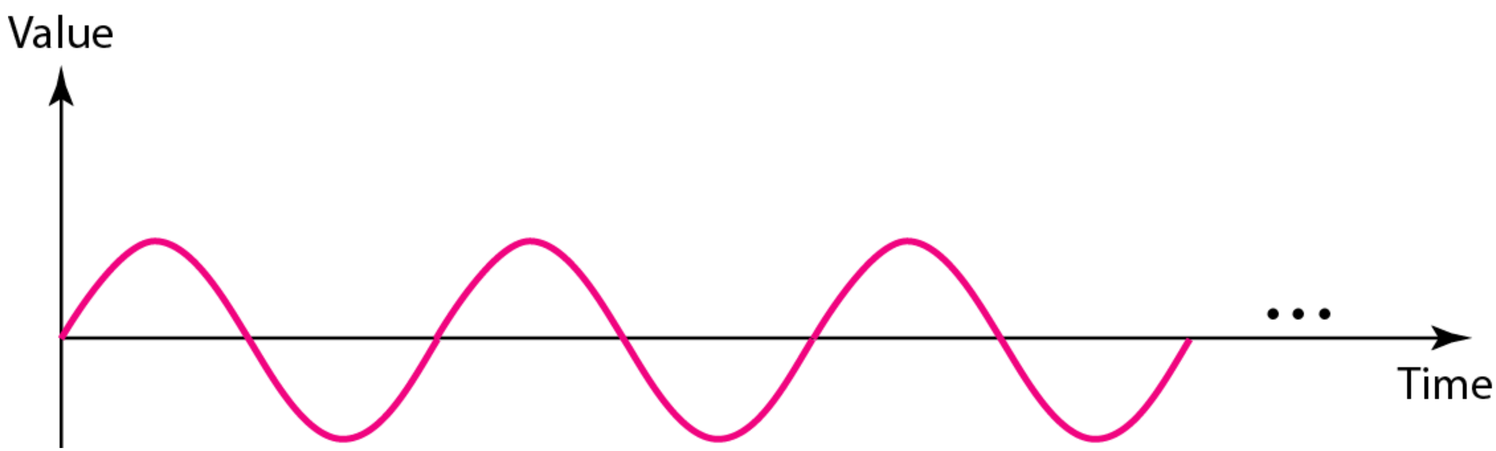
Analog and Digital Signals



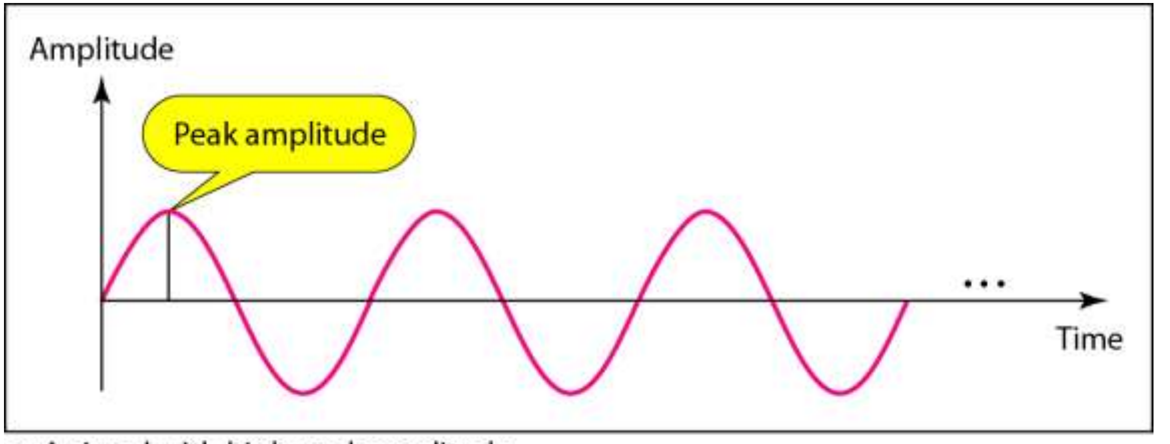
Analog signal
Continuous time
Continuous amplitude

Digital signal
Discrete time,
Discrete amplitude

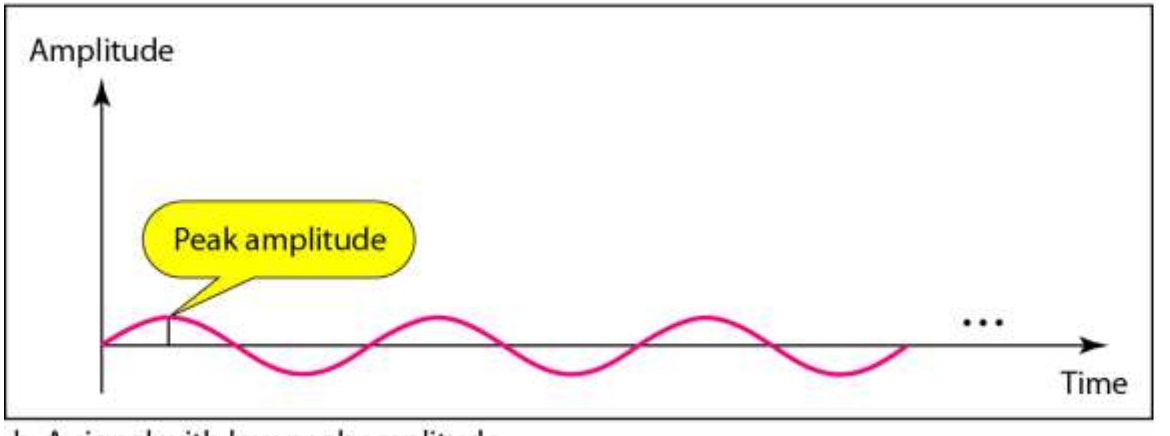
A sine wave



Two signals with the same phase and frequency, but different amplitudes



a. A signal with high peak amplitude



b. A signal with low peak amplitude

Frequency

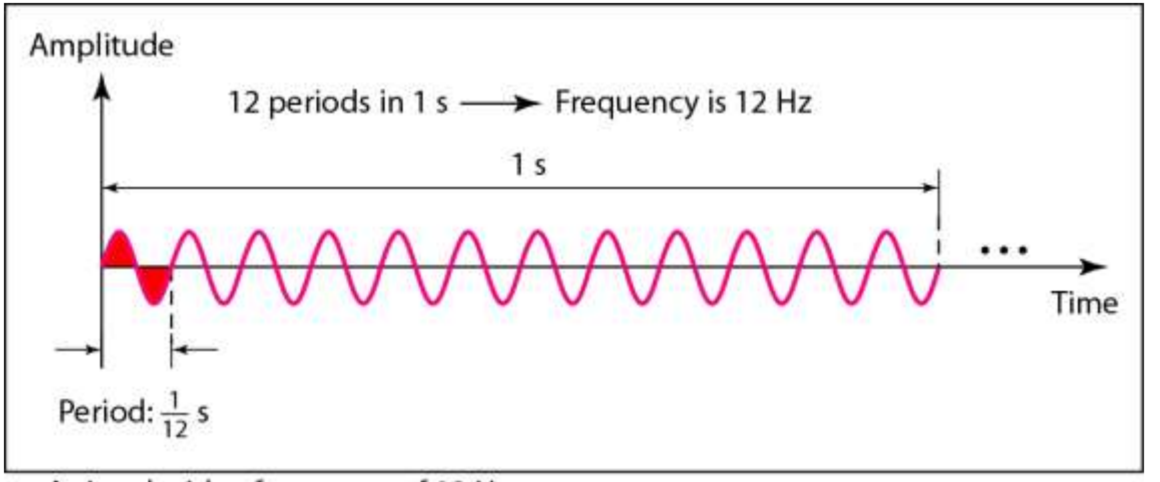
- Frequency is the rate of change with respect to time.
- Change in a short span of time means high frequency.
- Change over a long span of time means low frequency.

- **If a signal does not change at all, its frequency is zero.**
- **If a signal changes instantaneously, its frequency is infinite.**

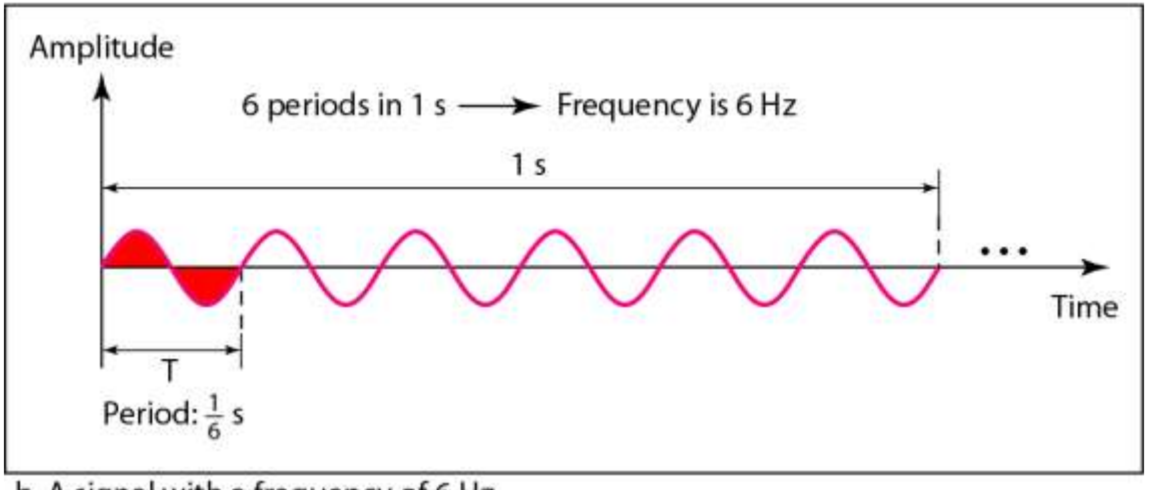
Frequency and period are the inverse of each other.

$$f = \frac{1}{T} \quad \text{and} \quad T = \frac{1}{f}$$

Figure 3.4 Two signals with the same amplitude and phase, but different frequencies



a. A signal with a frequency of 12 Hz



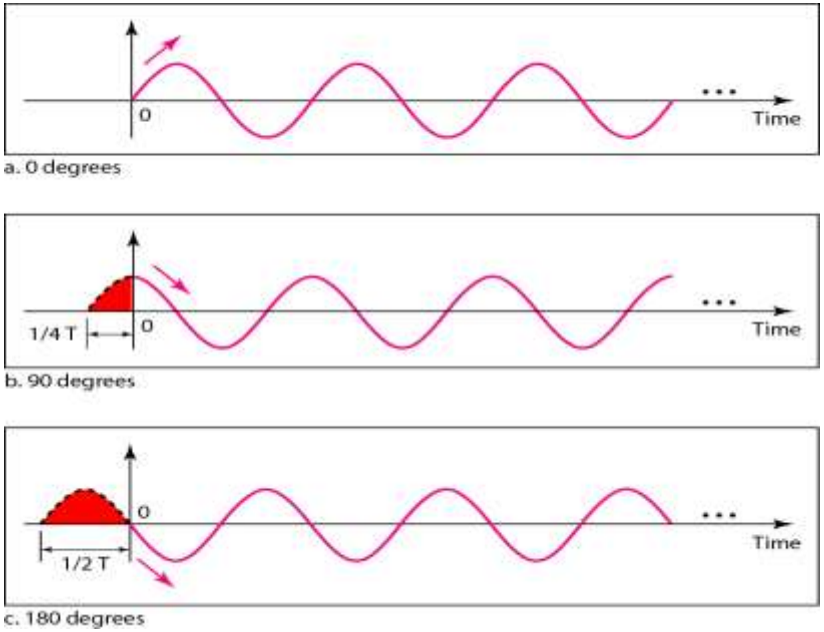
b. A signal with a frequency of 6 Hz

Table 3.1 Units of period and frequency

Unit	*Equivalent*	*Unit*	*Equivalent*
Seconds (s)	1 s	Hertz (Hz)	1 Hz
Milliseconds (ms)	10^{-3} s	Kilohertz (kHz)	10^{3} Hz
Microseconds (μs)	10^{-6} s	Megahertz (MHz)	10^{6} Hz
Nanoseconds (ns)	10^{-9} s	Gigahertz (GHz)	10^{9} Hz
Picoseconds (ps)	10^{-12} s	Terahertz (THz)	10^{12} Hz

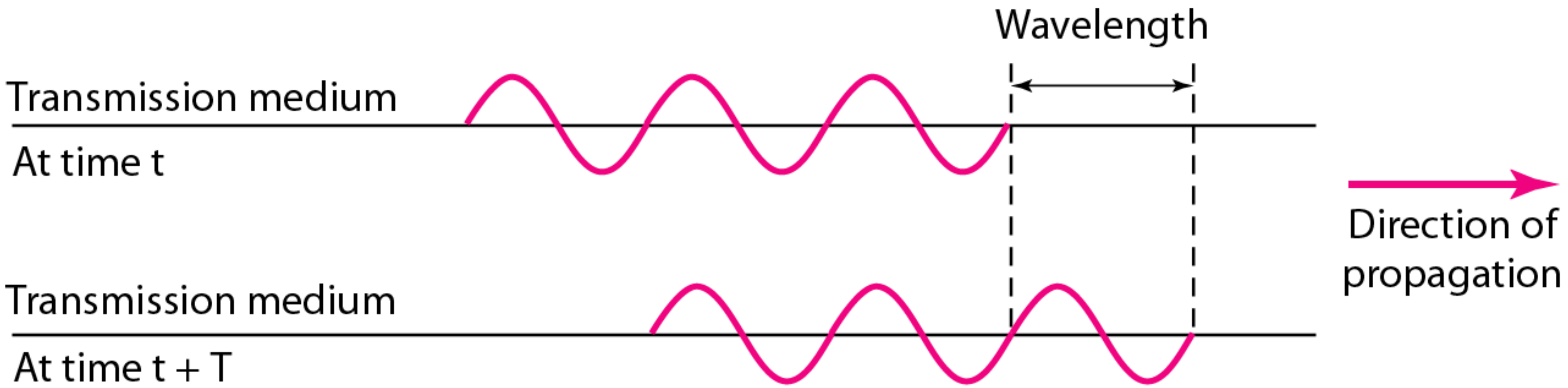
Phase

- Phase describes the position of the waveform relative to time 0.

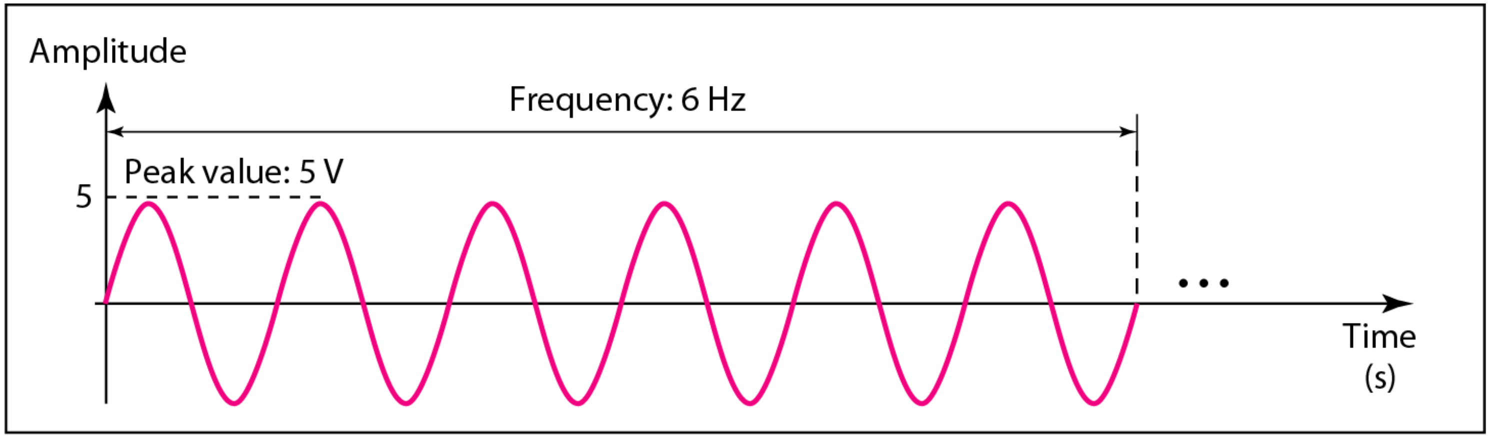


Three sine waves with the same amplitude and frequency, but different phases

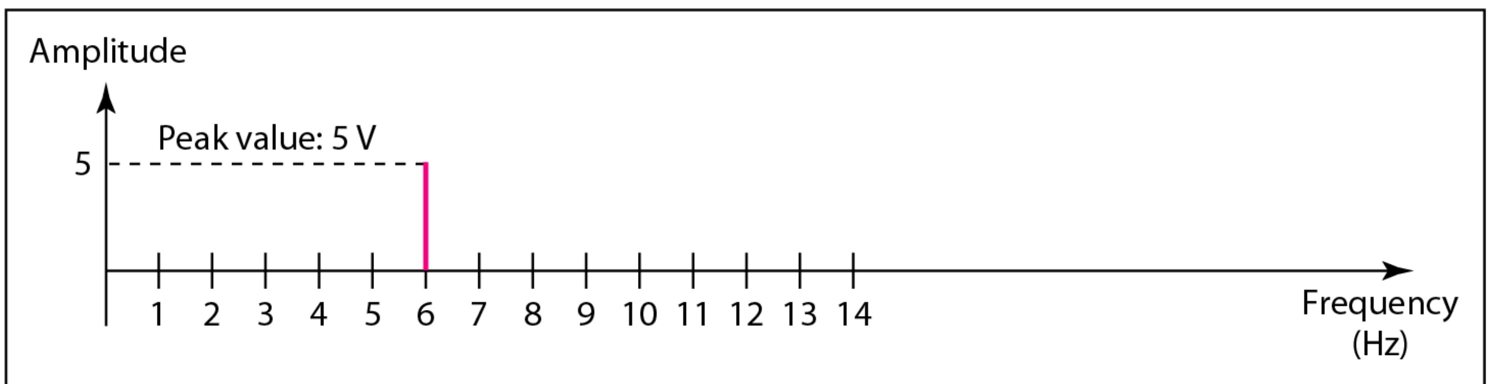
Wavelength and period



Time domain versus Frequency Domain



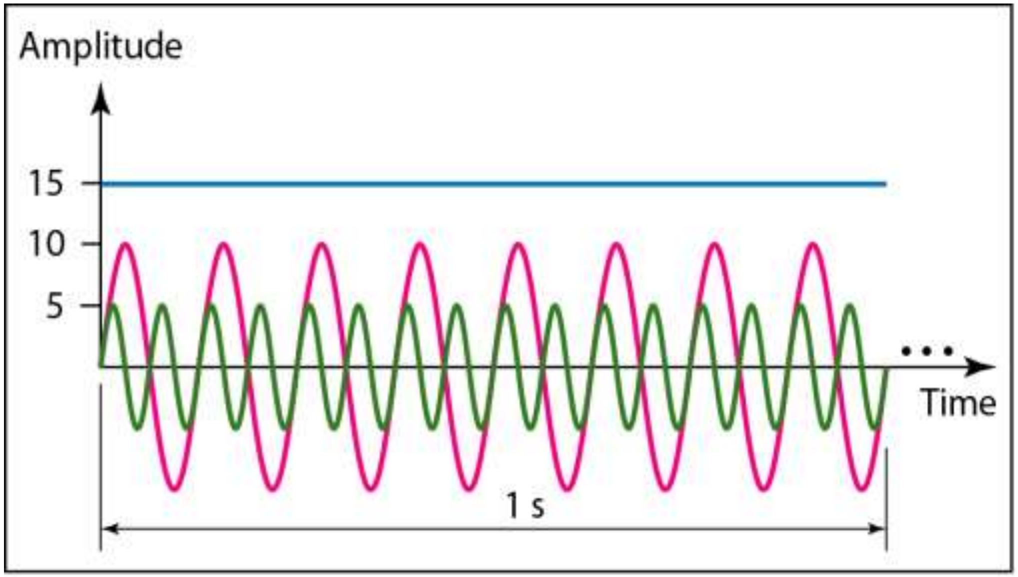
a. A sine wave in the time domain (peak value: 5 V, frequency: 6 Hz)



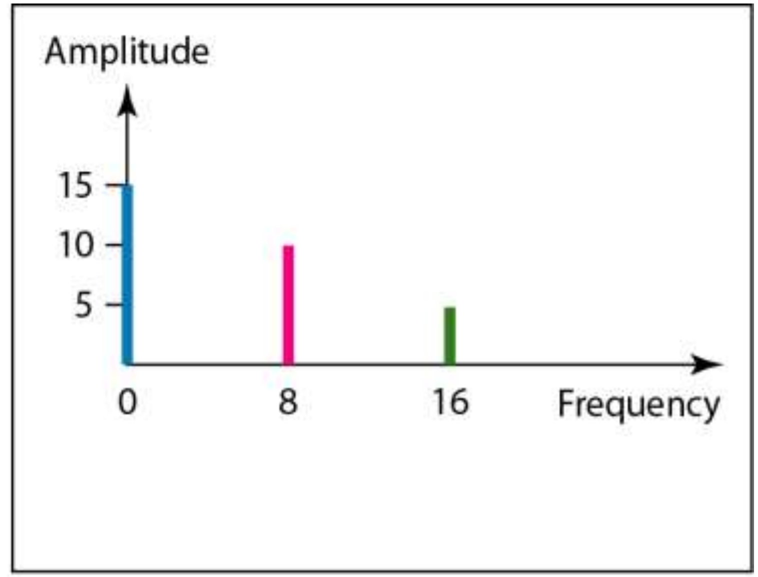
b. The same sine wave in the frequency domain (peak value: 5 V, frequency: 6 Hz)

A complete sine wave in the time domain can be represented by one single spike in the frequency domain.

The time domain and frequency domain of three sine waves



a. Time-domain representation of three sine waves with frequencies 0, 8, and 16

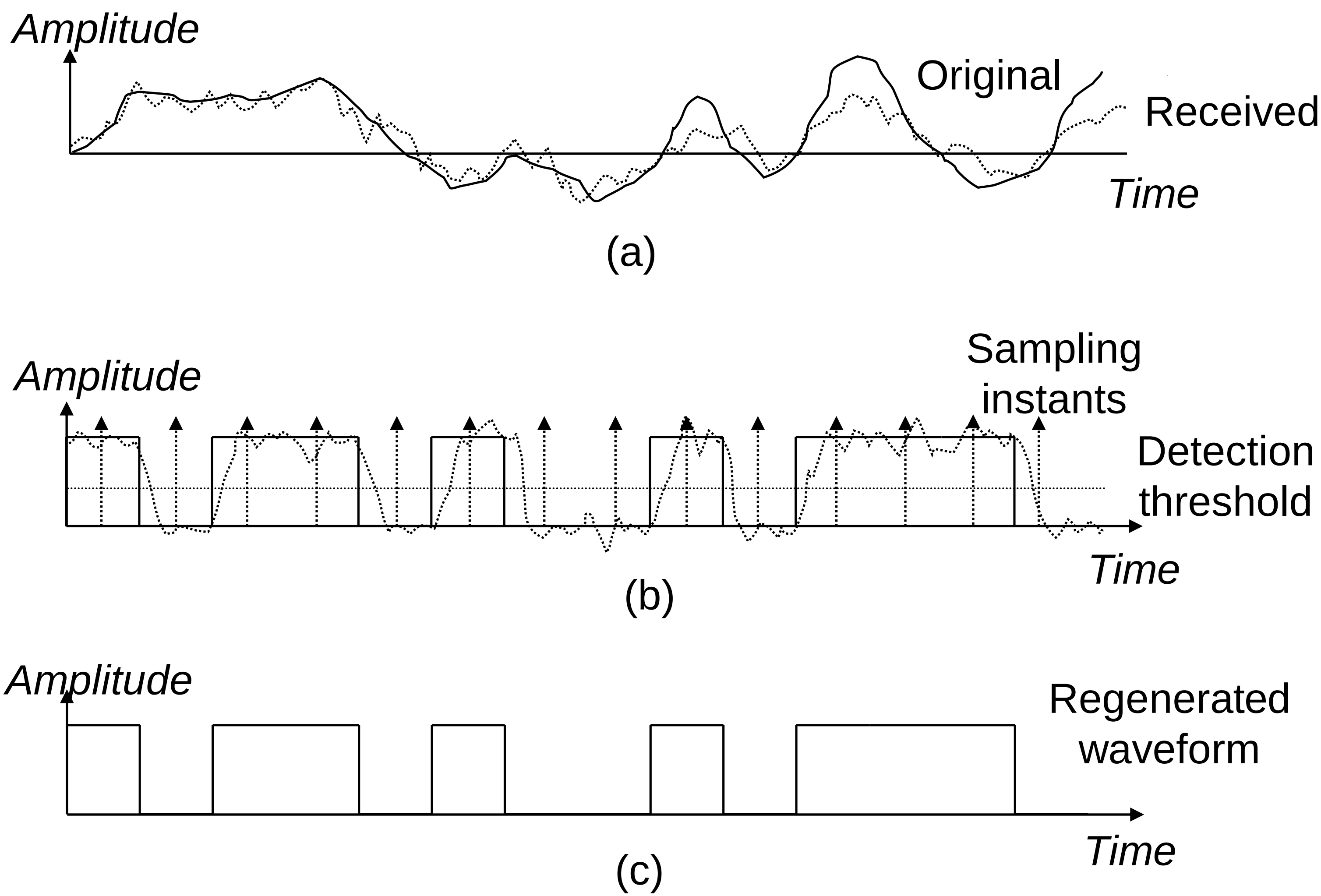


b. Frequency-domain representation of the same three signals

Advantages of Digital Signals

- Digital signals can be regenerated
- Digital modulators are more power and bandwidth efficient
- Efficient trade-off between power and bandwidth
- Signal compression
- Error detection and correction
- Common signal format for all types of signals
- Design flexibility and miniaturization through VLSI, EPLD, DSP, FPGA technology

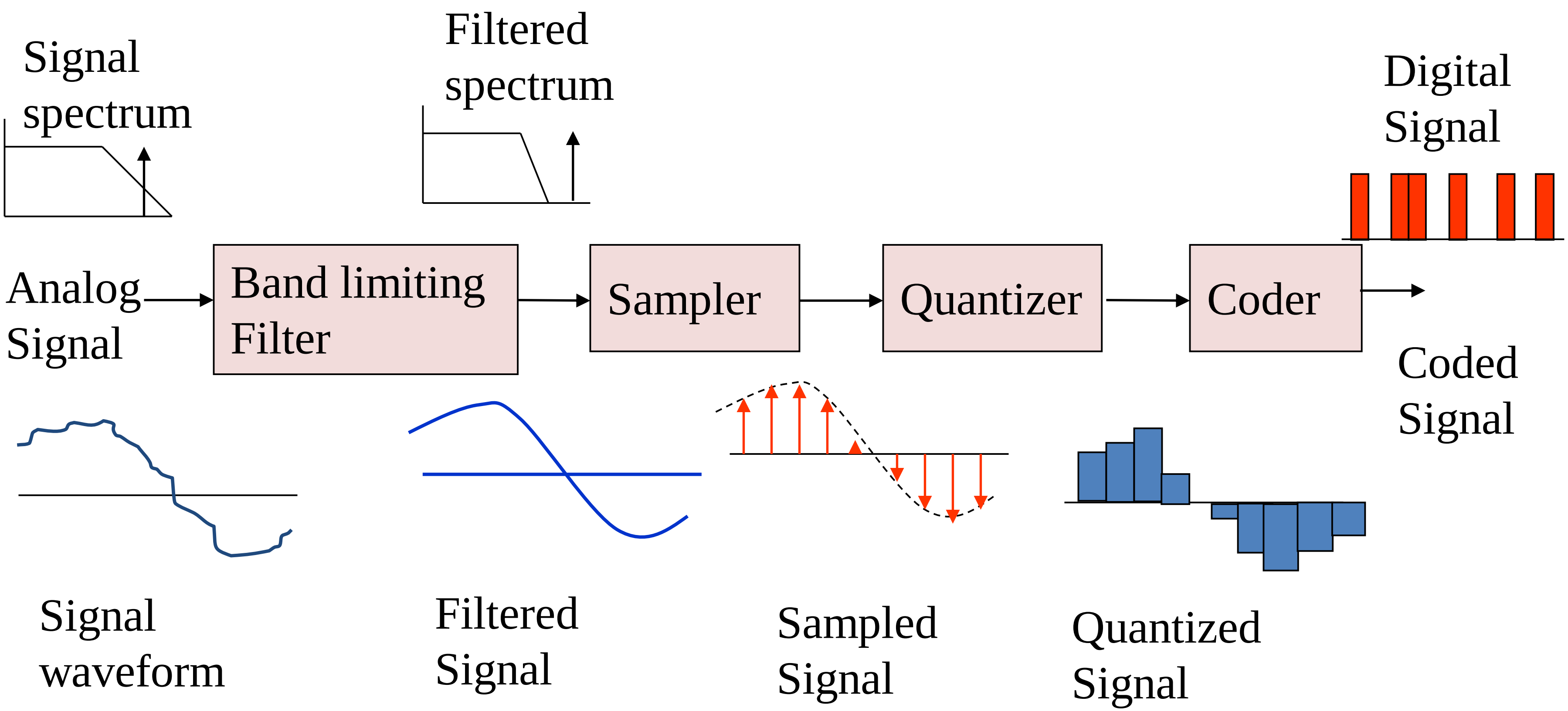
Digital Signal Regeneration



Analog to Digital Conversion

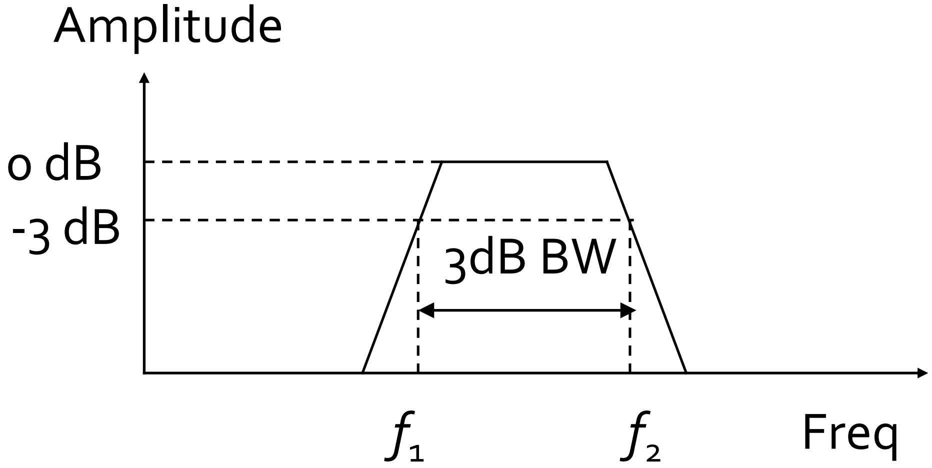
- Band limiting
  - Limit signal frequency band to Nyquist frequency
- Sampling
  - Changing continuous signal to discrete-time signal
  - Lossless process (if done at Nyquist rate)
- Quantization
  - Approximating continuous amplitude to discrete- levels
  - Lossy process
- Coding
  - Encoding discrete sample amplitudes to binary numbers

Analog to Digital Conversion

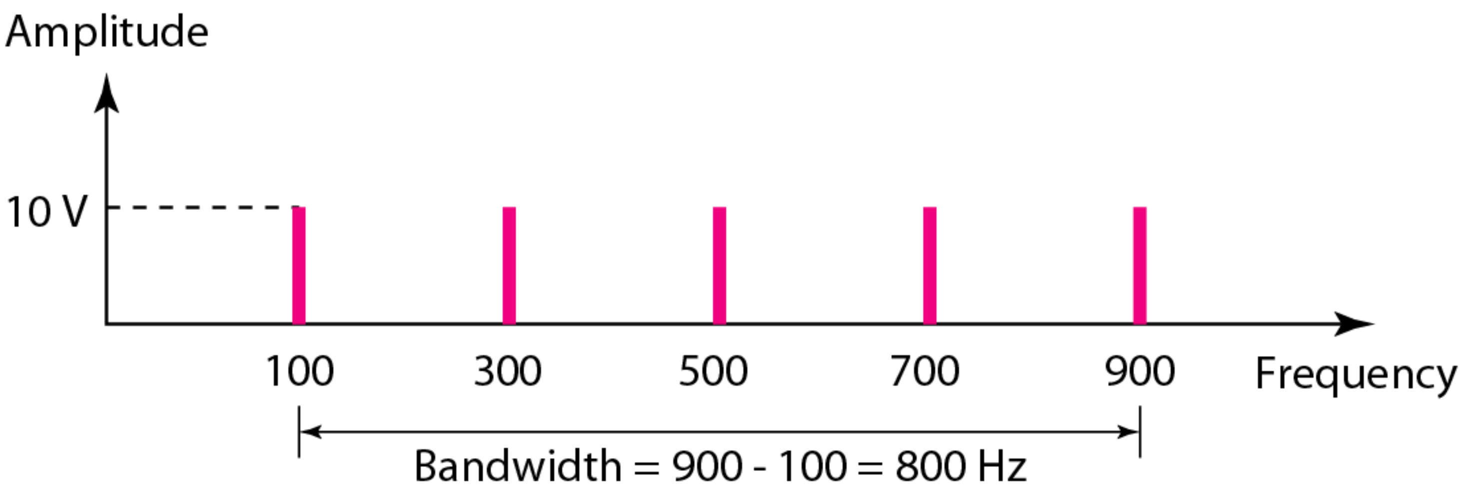


Bandwidth

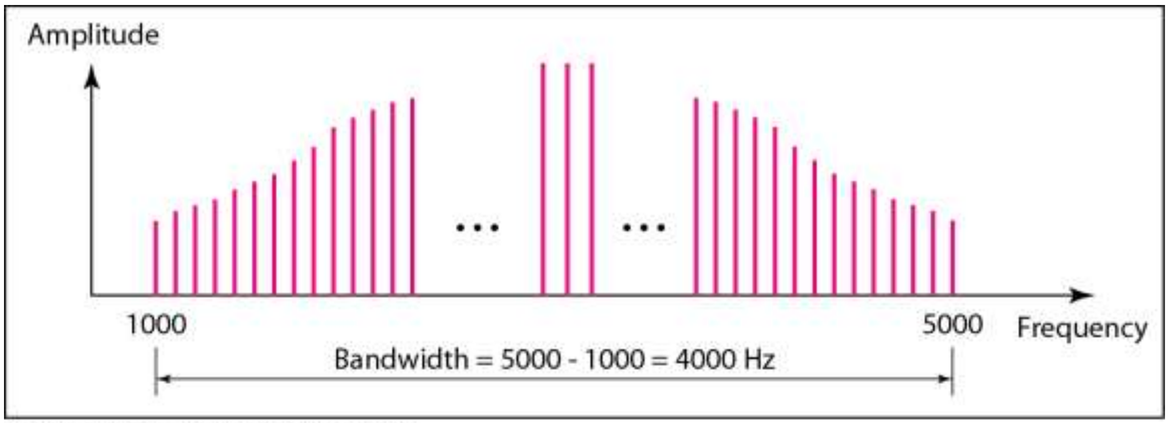
- Bandwidth is the difference ($f_{max} - f_{min}$)
- Bandwidth of a signal can be found by looking at the signal spectrum, obtained through Fourier transform
- Bandwidth of a channel is found by measuring its frequency response.



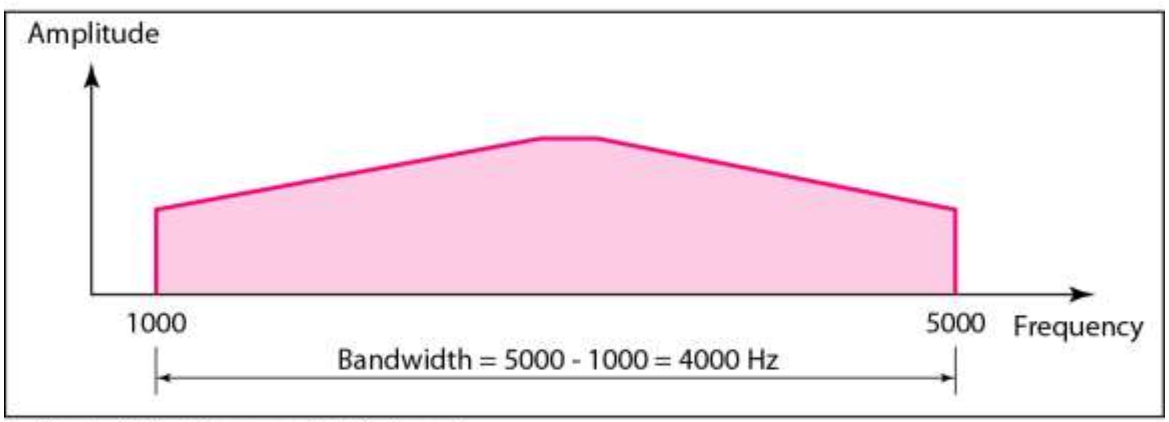
Example-Bandwidth



The bandwidth of periodic and non-periodic composite signals



a. Bandwidth of a periodic signal



b. Bandwidth of a nonperiodic signal

Example: Bandwidth

- If a periodic signal is decomposed into five sine waves with frequencies of 100, 300, 500, 700, and 900 Hz, what is its bandwidth? Draw the spectrum, assuming all components have a maximum amplitude of 10 V.
- Solution
- Let f_h be the highest frequency, f_l the lowest frequency, and B the bandwidth. Then

$$B = f_h - f_l = 900 - 100 = 800 \text{ Hz}$$

- The spectrum has only five spikes, at 100, 300, 500, 700, and 900 Hz (see Figure 3.13).

Examples of Bandwidth

1. Telephone speech has frequency range of 300 – 3400 Hz
   Bandwidth of telephone speech is 3400-300 = 3.1 kHz

2. Video signal has frequency range of 50 Hz-5 MHz
   Bandwidth of video signal is 5 MHz-50 Hz ≈ 5MHz

3. A bandpass filter has cut-off frequencies of 65 & 75 MHz
   Bandwidth of the filter is 75-65 = 10 MHz

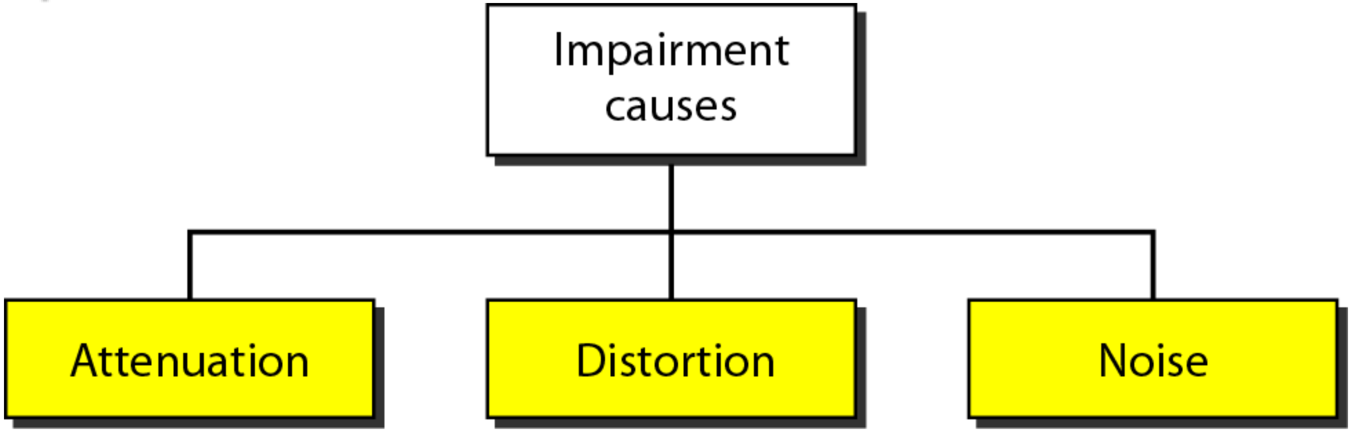
1 and 2 are examples of signal bandwidth, 3 is an example of system bandwidth

Bandwidth units

Multiple	Name	Symbol
10^0	Hertz	Hz
10^3	kilohertz	kHz
10^6	megahertz	MHz
10^9	gigahertz	GHz
10^{12}	terahertz	THz

Signal Impairments

- Signals travel through transmission media, which are not perfect. The imperfection causes signal impairment. This means that the signal at the beginning of the medium is not the same as the signal at the end of the medium. What is sent is not what is received. Three causes of impairment are attenuation, distortion, and noise.



Attenuation

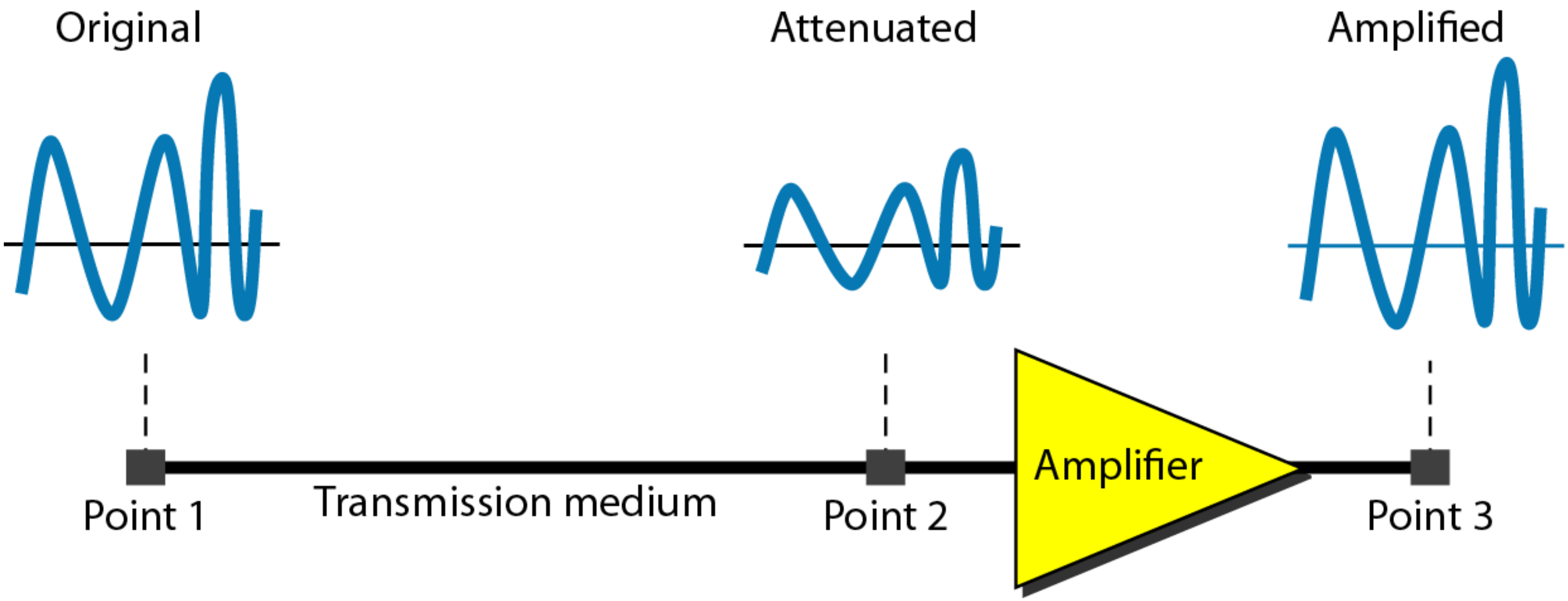
- Means loss of energy -> **weaker signal**
- When a signal travels through a medium it loses energy overcoming the resistance of the medium
- **Amplifiers** are used to compensate for this loss of energy by amplifying the signal.
- To show the loss or gain of energy the unit “decibel” is used.

$$dB = 10\log_{10} P_2/P_1$$

P_1 - input signal

P_2 - output signal

Attenuation



Example-1

- Suppose a signal travels through a transmission medium and its power is reduced to one-half. This means that P2 is (1/2)P1. In this case, the attenuation (loss of power) can be calculated as

$$10 \log_{10} \frac{P_2}{P_1} = 10 \log_{10} \frac{0.5 P_1}{P_1} = 10 \log_{10} 0.5 = 10(-0.3) = -3 \text{ dB}$$

- A loss of 3 dB (–3 dB) is equivalent to losing one-half the power.

Example-1

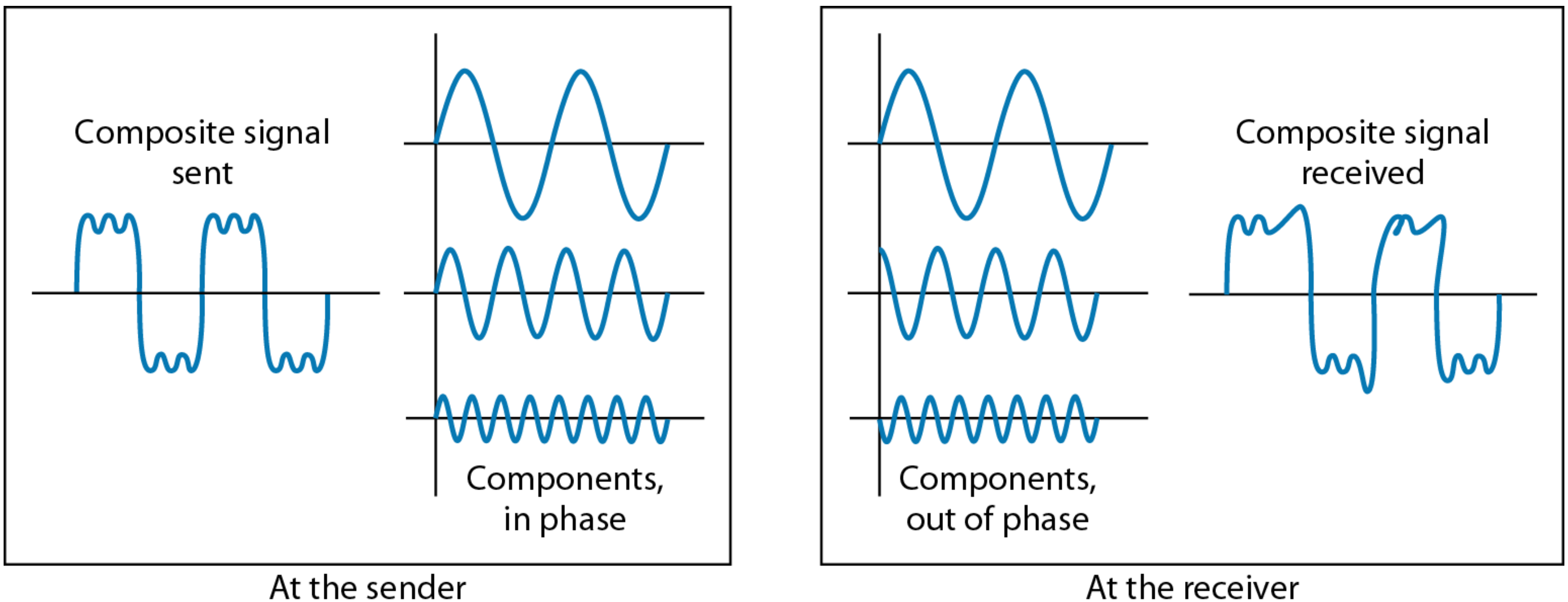
- A signal travels through an amplifier, and its power is increased 10 times. This means that $P_2 = 10P_1$. In this case, the amplification (gain of power) can be calculated as

$$10 \log_{10} \frac{P_2}{P_1} = 10 \log_{10} \frac{10P_1}{P_1}$$

$$= 10 \log_{10} 10 = 10(1) = 10 \text{ dB}$$

Distortion

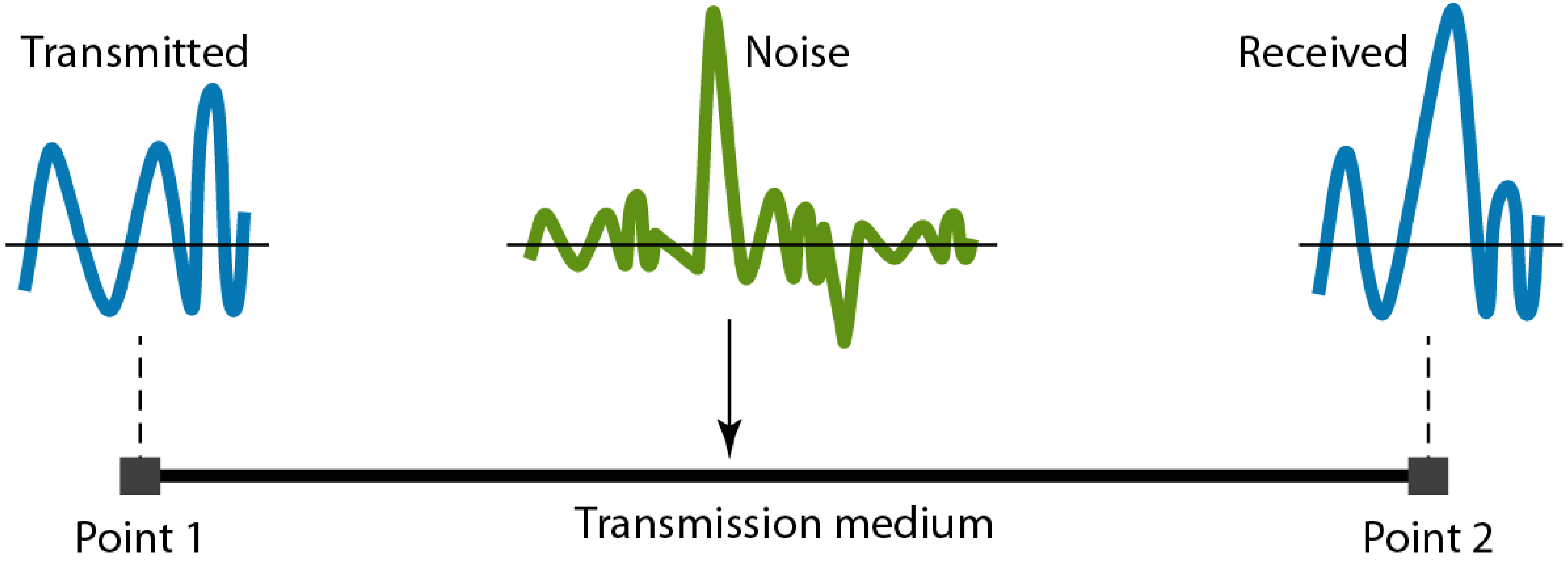
- **Means that the signal changes its form or shape**
- **Distortion occurs in composite signals**
- Each frequency component has its own propagation speed traveling through a medium.
- The different components therefore arrive with different delays at the receiver.
- That means that the signals have different phases at the receiver than they did at the source.


Composite signal sent
Components, in phase
At the sender
Components, out of phase
Composite signal received
At the receiver

Noise

- There are different types of noise
  - Thermal - random noise of electrons in the wire creates an extra signal
  - Induced - from motors and appliances, devices act as transmitter antenna and medium as receiving antenna.
  - Crosstalk - same as above but between two wires.
  - Impulse - Spikes that result from power lines, lightning, etc.

Noise


Transmitted
Noise
Received
Point 1
Transmission medium
Point 2

Signal to Noise ratio

- To measure the quality of a system the SNR is often used. It indicates the strength of the signal wrt the noise power in the system.
- It is the ratio between two powers.
- It is usually given in dB and referred to as $SNR_{dB.}$

Example-2

- The power of a signal is 10 mW and the power of the noise is 1 μW; what are the values of SNR and SNR_{dB} ?

- Solution
- The values of SNR and SNRdB can be calculated as follows:

$$SNR = \frac{10{,}000\ \mu W}{1\ mW} = 10{,}000$$

$$SNR_{dB} = 10 \log_{10} 10{,}000 = 10 \log_{10} 10^4 = 40$$

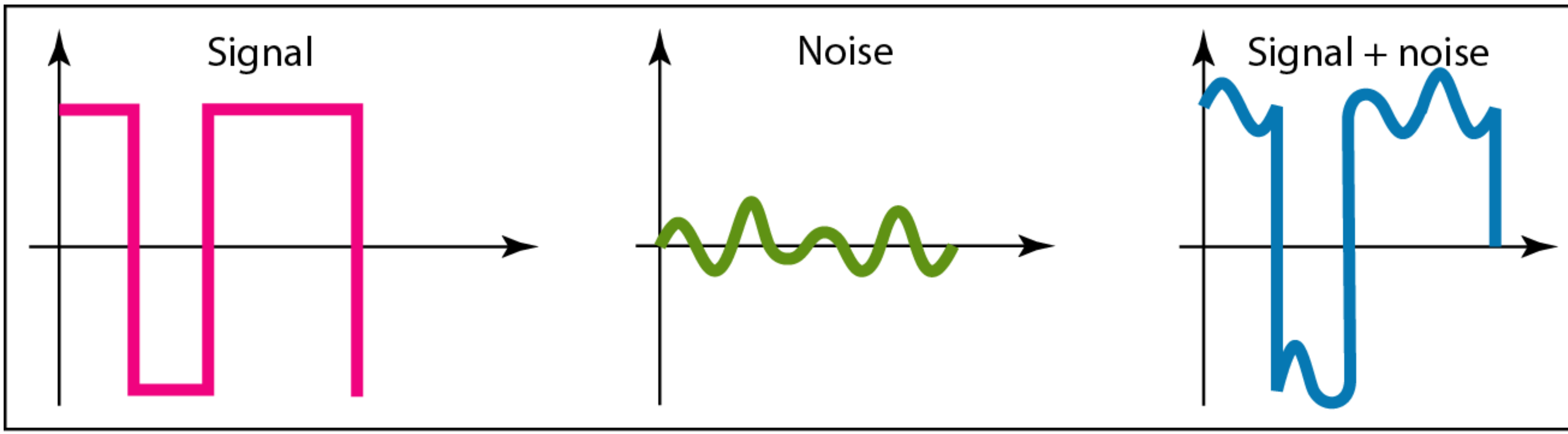
Example-2

- The values of SNR and SNRdB for a noiseless channel are

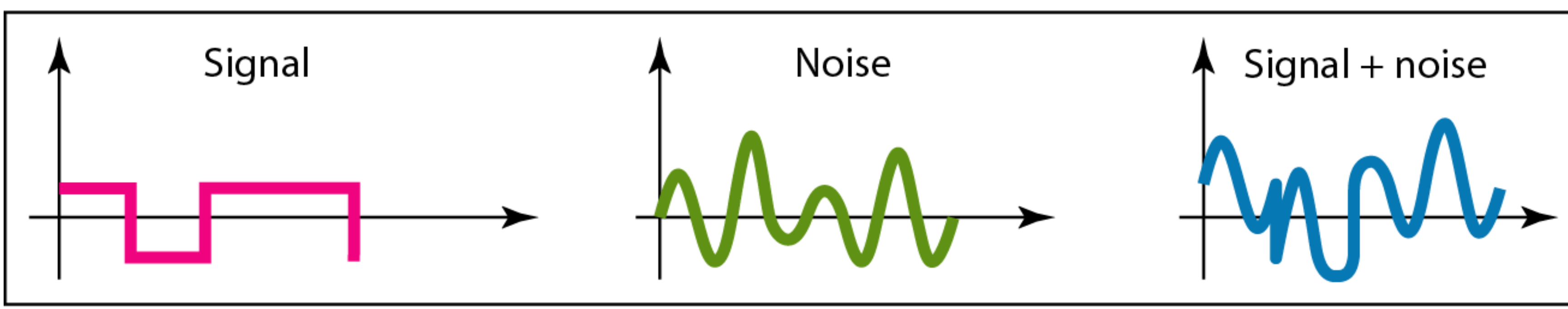
$$\text{SNR} = \frac{\text{signal power}}{0} = \infty$$

$$\text{SNR}_{\text{dB}} = 10 \log_{10} \infty = \infty$$

- We can never achieve this ratio in real life; it is an ideal.



a. Large SNR



b. Small SNR

List of Communication Applications

- AM and FM radio
- TV broadcasting
- Digital TV
- Wireless remote control
- Internet
- Internet radio and video
- Navigation and direction finding services. i.e. GPS
- Telephones and mobile phones
- RADAR
- Radio astronomy

Modulation and its need

- Modulation is the process of mapping the modulating signal or information signal onto the high frequency carrier.
- In modulation out either amplitude, phase or frequency of the carrier signal is changed in accordance with the modulating signal and we have AM, PM and FM
- In case of analog modulation techniques(AM,PM, FM) the carrier signal and modulating signal are both in analog form.
- While for digital modulation techniques the modulating signal is digital but the carrier is still analog due to its high frequency nature.

Advantages achieved using modulation

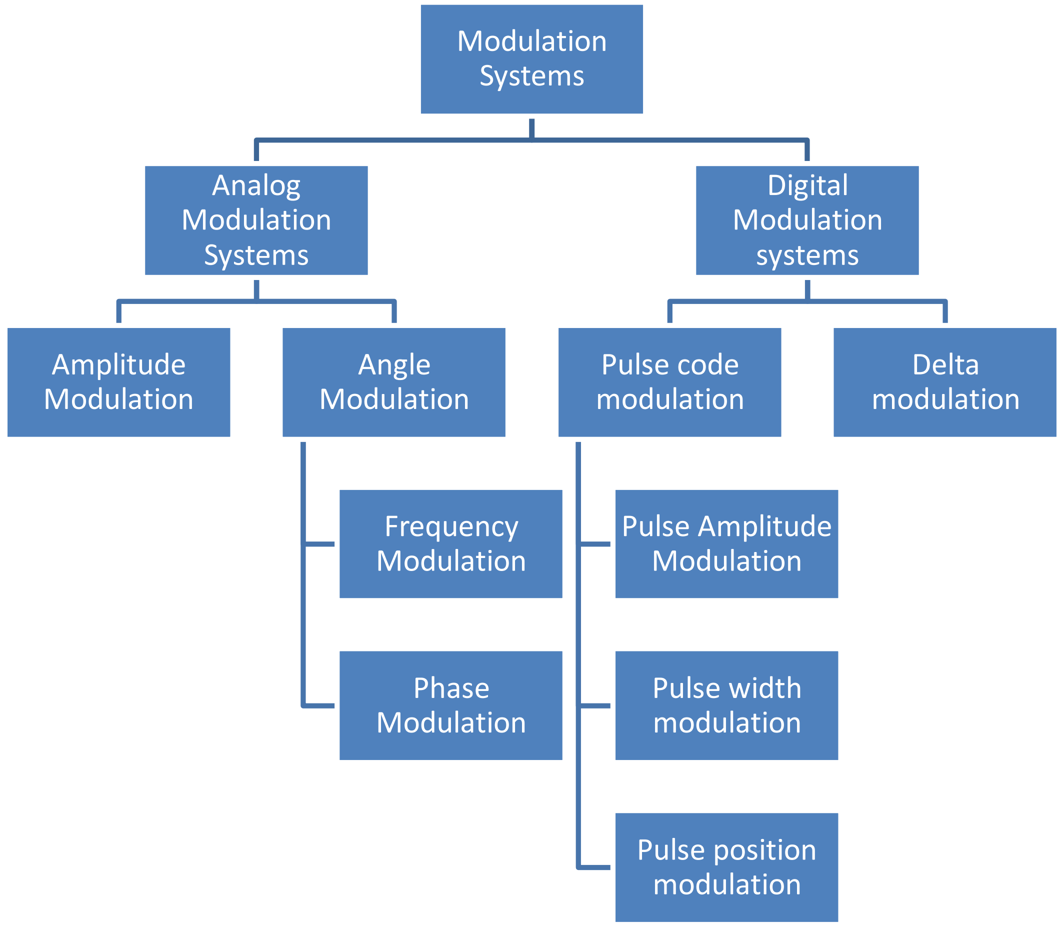
- Reduction in height of antenna
- Avoids mixing of signal
- Increase in the range of communication
- Multiplexing is possible

Reduction in antenna height

- For the transmission of radio signals, the antenna height must be multiple of (lambda/4).
- Here the wavelength lambda = (c / f)
- Minimum antenna height =(lambda/4)=c/(4*f)

- Calculate for f = 10 kHz and compare it with f=1 MHz

Different types of Modulation system



Types of Analog Modulation

- Amplitude Modulation (AM)

  Amplitude modulation is the process of ***varying the amplitude of a carrier wave in proportion to the amplitude of a baseband signal.*** The frequency of the carrier remains constant

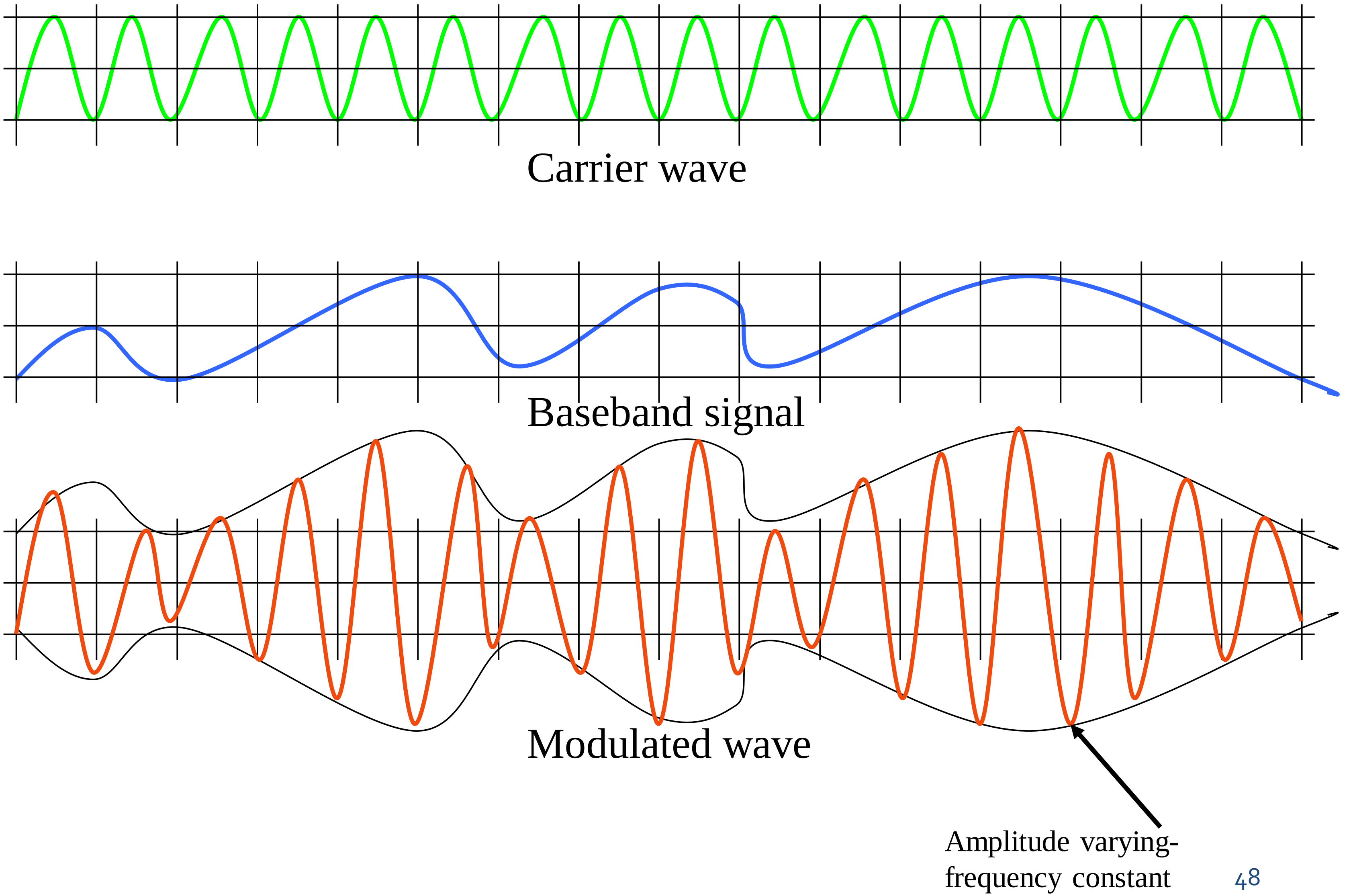
- Frequency Modulation (FM)

  Frequency modulation is the process of ***varying the frequency of a carrier wave in proportion to the amplitude of a baseband signal.*** The amplitude of the carrier remains constant

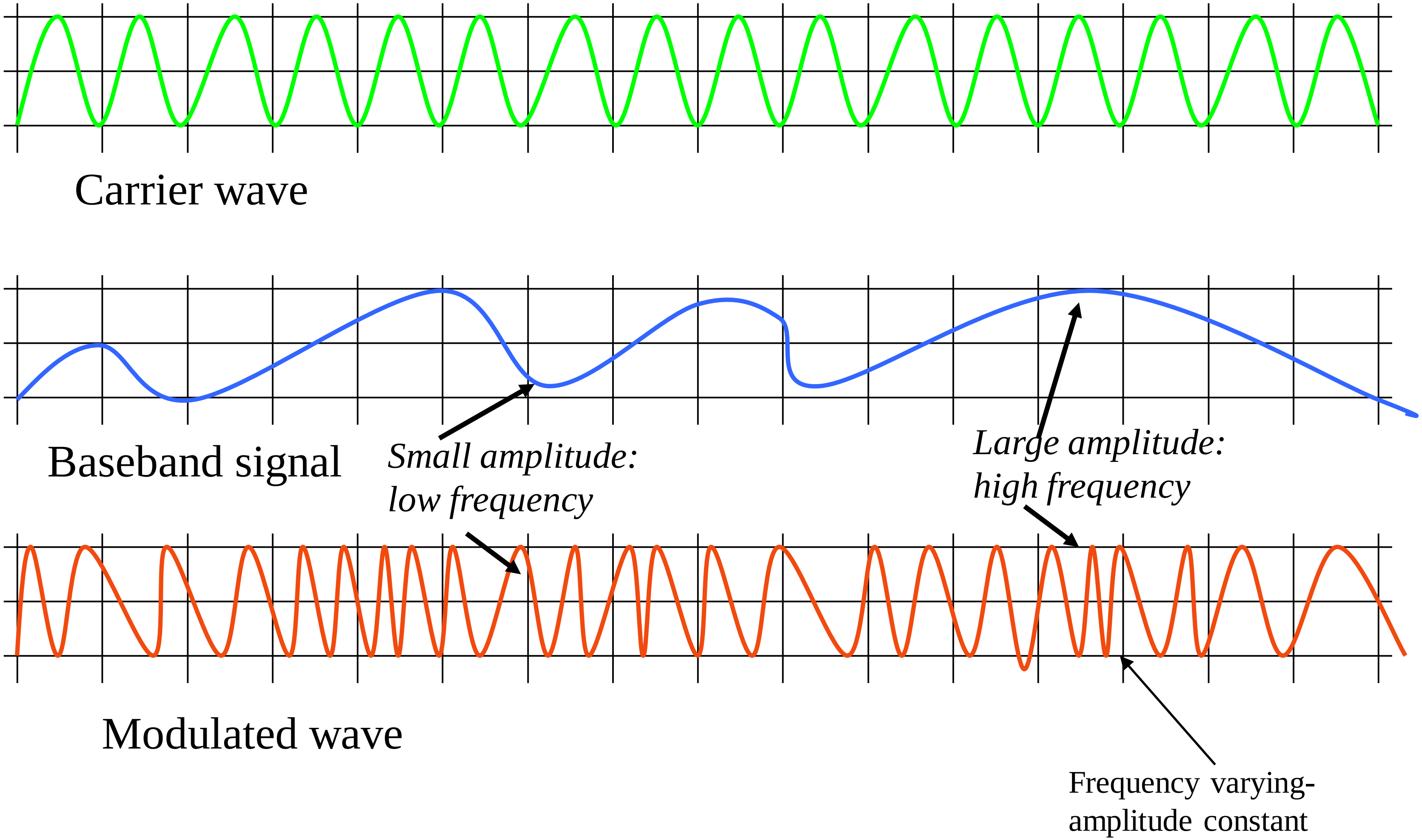
- Phase Modulation (PM)

  Another form of analog modulation technique.

Amplitude Modulation

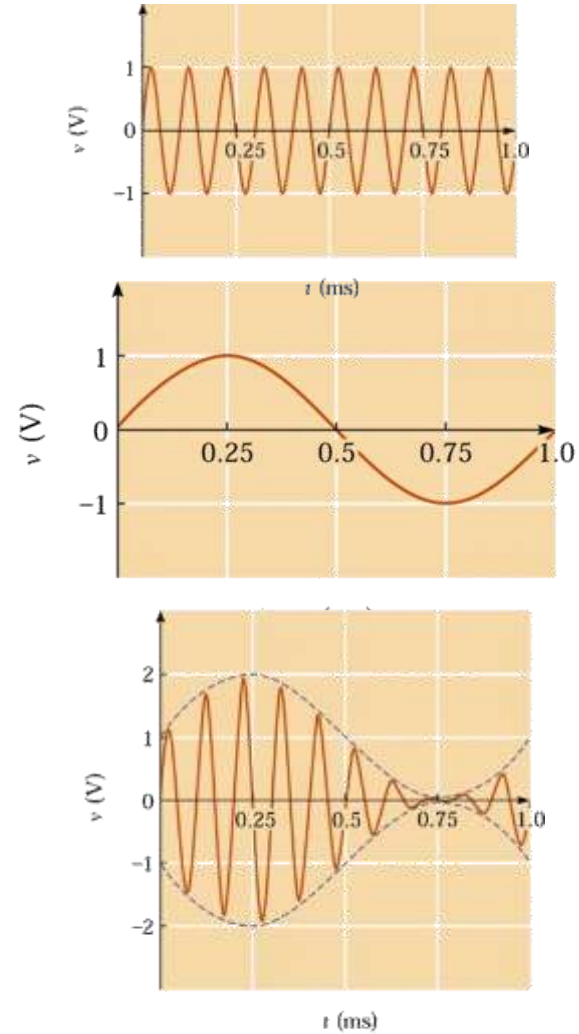


Frequency Modulation



Basic Amplitude Modulation

- When the amplitude of high frequency carrier wave is changed in accordance with the intensity of the signal, it is called amplified modulation.



Amplitude Modulation

- Amplitude of the high frequency carrier wave changes according to the intensity of the signal.

- The amplitude variations of the carrier wave are at the signal frequency FM.

- The frequency of the Amplitude modulated wave remains the same i.e. carrier frequency fc.

Modulation Index

Modulation index describes the depth of modulation i.e. the extent to which the amplitude of carriers wave is changed by the signal.

$$m = V_m / V_c$$

The modulation index is a number lying between 0 and 1 and it is may often expressed as a percentage and called the percentage modulation.

Frequency spectrum of the AM wave

$Vc = Vc \sin \omega ct$

$Vm = Vm \sin \omega mt$

$m = Vm / Vc$

Amplitude of the AM wave will be

$A = Vc + Vm$

$= Vc + Vm \sin \omega mt$

$= Vc + m\, Vc \sin \omega mt$

$= Vc [1 + m \sin \omega mt]$

Frequency spectrum of the AM wave

- The instantaneous voltage of the resulting AM wave is $A \sin\theta$

- $V = A \sin \omega ct$

  $= V_c [1 + m \sin \omega mt] \sin \omega ct$

  $= V_c \sin \omega ct + m V_c \sin \omega mt \sin \omega ct$

- $V = V_c \sin \omega ct + mV_c/2 \cos(\omega c - \omega m)t -$

  $mV_c/2 \cos(\omega c + \omega m)t$

Frequency spectrum of the AM wave

- Three terms,
  - **Un-modulated carrier.**
  - **Two sideband LSB and USB**

    (fc – fm) (fc + fm)
  - **Effect of adding rather than change.**

- The bandwidth required for AM wave is twice the frequency of modulating signal.

Frequency spectrum of the AM wave

- AM wave is equivalent to the summation of three sinusoidal waves,
  - one having amp. Vc freq. fc,
  - Second having amp. mVc/2, freq.(fc – fm),
  - Third having amp. mVc/2 freq. fc + fm.

- The AM wave contains three frequency,
  - fc,
  - fc + fm, USB
  - fc – fm, LSB,

Sideband Frequencies in AM wave

- In an AM wave, the sideband frequency waves are of own interest. It is because the signal fm is contained in the sideband frequency.

- In partial radio transmission, carrier frequency fc is much higher than signal frequency fm. Hence sideband a frequency are much closed to carrier frequency.

Suppose fc = 400 KHz.

Signal frequency fm = 1 KHz.

USB = 400 + 1 = 401 KHz.

LSB = 400 - 1 = 399 KHz.

400 and 399 is very close to 400 KHz.

Sideband Frequencies in AM wave

Bandwidth → In an AM wave, the bandwidth is from (fc – fm) to (fc + fm) i.e. 2 fm.

This BW = 401 – 399 = 2 KHz.

Which is twice the signal frequency.

In Amplitude Modulation Bandwidth is twice the signal frequency.

Bandwidth

- Signal bandwidth is an important characteristic of any modulation scheme
- In general, a narrow bandwidth is desirable
- Bandwidth is calculated by:

$$B = 2F_m$$

Angle Modulation

$$m(t) = V_c \cos[\omega_c t + \theta(t)]$$

where $m(t) =$ Angle modulated signal

$V_c =$ Peak amplitude of carrier (volts)

$\omega_c =$ Radian frequency of carrier $= 2\pi f_c$

$\theta(t) =$ Instantane ous phase deviation

Angle Modulation

If $v_m(t)$ is the instataneo us amplitude of a modulating signal, the angle modulation is expressed as

$\theta(t) \propto v_m(t)$

Concept of frequency

- 1Hz = 1 revolution/sec

  = 2π rad/sec

- f Hz = f revolutions/sec

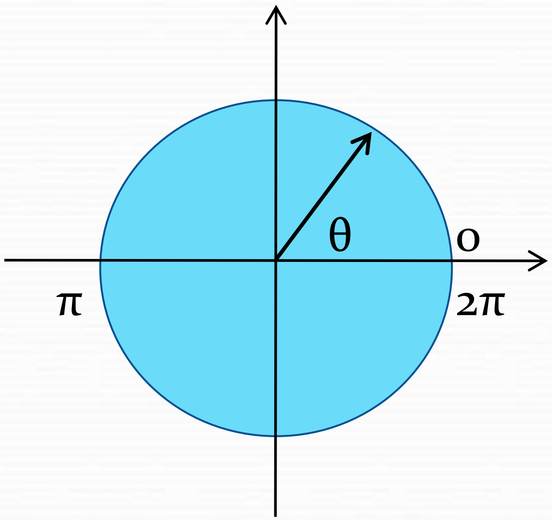
  = f.2π radians/sec

- Radian Frequency

  = angle covered in one second

  = rate of change of angle θ

- $\omega = d\theta/dt$



FM and PM

- In both FM and PM the phase angle of the carrier is varied with the instantaneous amplitude of the modulating signal
- In **FM**, the carrier frequency is varied in proportion to the instantaneous amplitude of the modulating signal, or the phase is varied in proportion to the integral of the modulating signal amplitude
- In **PM**, the carrier phase is varied in proportion to the instantaneous amplitude of the modulating signal, or the frequency is varied in proportion to the rate of change (derivative or slope) of the modulating signal amplitude

FM and PM

- The amount by which the carrier frequency is varied from its unmodulated value, called deviation, is made proportional to the instantaneous amplitude of modulating voltage
- The rate at which this frequency variation changes is equal to the modulating frequency

FM and PM

FM

$$\omega_c \propto v_m$$

$$\omega_c = k_f v_m$$

$$\omega_c = \frac{d}{dt}\{\theta(t)\} \propto v_m$$

$$\theta(t) \propto \int v_m dt$$

PM

$$\theta(t) \propto v_m$$

$$\theta(t) = k_p v_m$$

$$\theta(t) = \int \omega_c dt$$

$$\omega_c = k\frac{d}{dt}(v_m)$$

FM and PM

For phase modulation $\theta(t) = k_p v_m(t)$

$$m(t)_{pm} = V_c \cos\left[\omega_c t + \theta(t)\right]$$

$$= V_c \cos\left[\omega_c t + k_p v_m(t)\right]$$

$$= V_c \cos\left[\omega_c t + k_p V_m \cos(\omega_m t)\right]$$

For frequency modulation $\theta(t) = k_f \int v_m(t) dt$

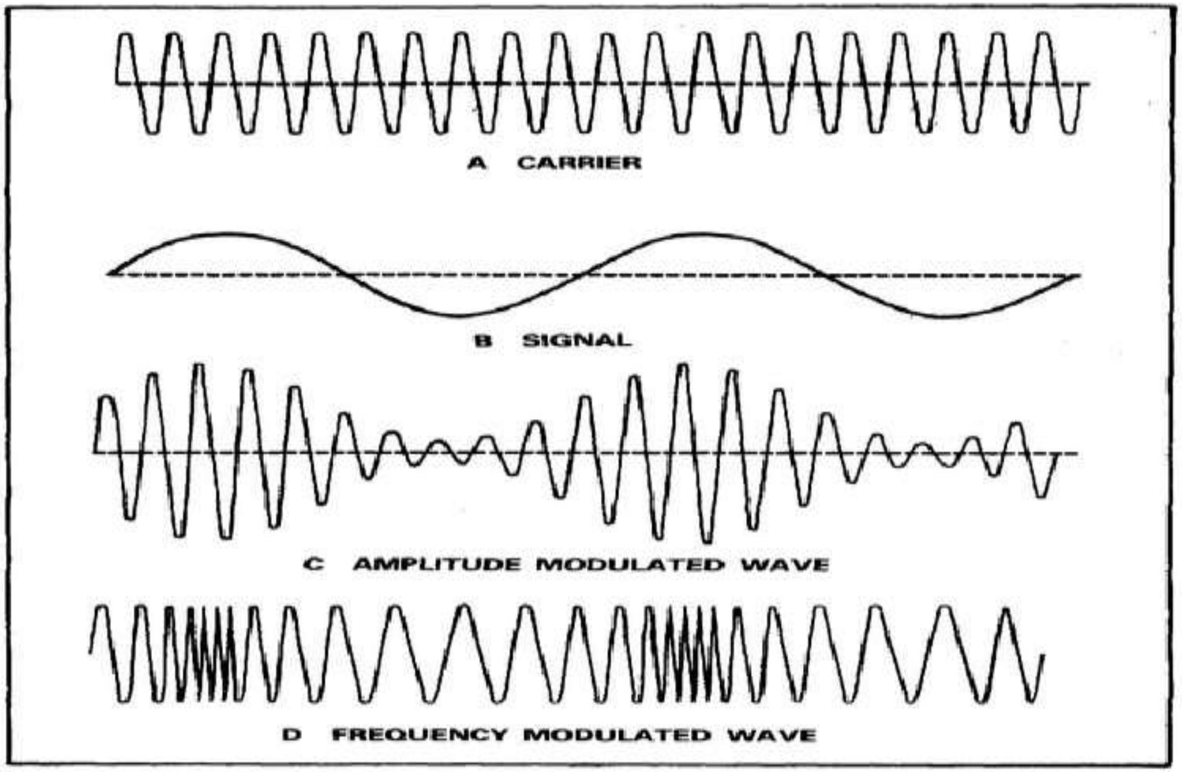
$$m(t)_{pm} = V_c \cos\left[\omega_c t + \theta(t)\right]$$

$$= V_c \cos\left[\omega_c t + k_f \int v_m(t) dt\right]$$

$$= V_c \cos\left[\omega_c t + k_f \int V_m \cos(\omega_m t) dt\right]$$

$$= V_c \cos\left[\omega_c t + \frac{k_f V_m}{\omega_m} \sin(\omega_m t)\right]$$

FM and PM



A CARRIER
B SIGNAL
C AMPLITUDE MODULATED WAVE
D FREQUENCY MODULATED WAVE

FM and PM

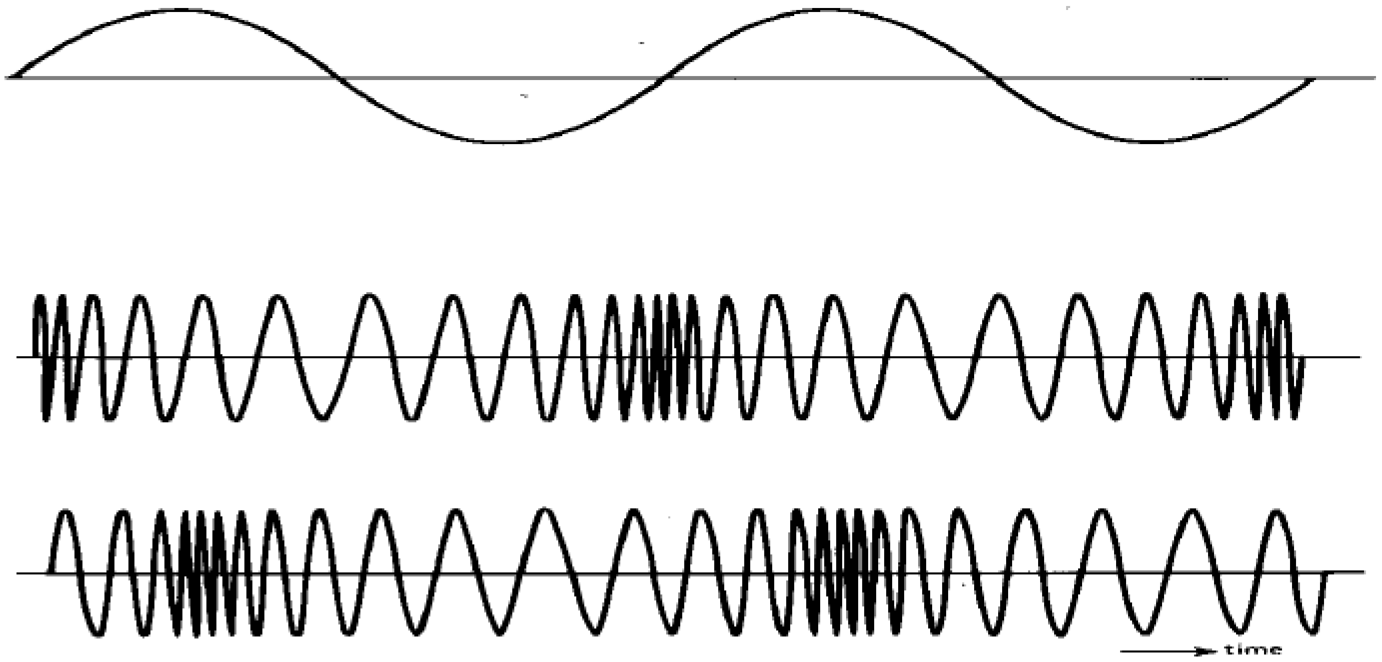


Fig: 5.1 – PM and FM Waveforms with a message signal

Phase deviation and modulation index

$$m(t)_{pm} = V_c \cos\left[\omega_c t + k_p V_m \cos(\omega_m t)\right]$$
$$= V_c \cos\left[\omega_c t + m_p \cos(\omega_m t)\right]$$

where $m_p = k_p V_m = \Delta\theta = \text{modulation index} = \text{peak phase deviation (radians)}$

$k_p = \text{deviation sensitivity (radians per volt)}$

$V_m = \text{peak amplitude of modulating signal (volts)}$

Modulation index in FM

$$m(t)_{fm} = V_c \cos[\omega_c t + \theta(t)] = V_c \cos\left[\omega_c t + k_f \int v_m(t) dt\right]$$

$$= V_c \cos\left[\omega_c t + k_f \int V_m \cos(\omega_m t) dt\right] = V_c \cos\left[\omega_c t + \frac{k_f V_m}{\omega_m} \sin(\omega_m t)\right]$$

$$= V_c \cos\left[\omega_c t + m_f \sin(\omega_m t)\right]$$

$$\text{where } m_f = \frac{k_f V_m}{\omega_m} = \text{modulation index}$$

$$k_f = \text{deviation sensitivity (Hz/volt)}$$

$$V_m = \text{peak amplitude of modulating signal (volts)}$$

$$\omega_m = \text{radian frequency (radians/second)}$$

If deviation sensityvity is expressed in Hz/volt

$$m_f = \frac{k_f V_m}{f_m} = \frac{\Delta f}{f_m}$$

Carson's rule for FM Bandwidth

$$B = 2(\Delta f + f_m) = 2 f_m (1 + \Delta f / f_m) = 2 f_m (1 + m) \text{ Hz}$$

where

Δf = peak frequency deviation (Hz)

f_m = highest modulating signal frequency (Hz)

m = modulation index $= \Delta f / f_m$

Example

- Carrier has frequency of 10.7 MHz and rms voltage of 7.07 volts
- A sinusoidal modulating signal has frequency of 15 kHz and rms voltage of 3.535 volts
- The modulator provides a frequency deviation of 15 kHz/volt
- Write the FM equation

Applications of Angle Modulation

- classified into two types such as
  - ***Frequency modulation (FM)***
  - ***Phase modulation (PM)***
- Used for :
  - Commercial radio broadcasting
  - Television sound transmission
  - Two way mobile radio
  - Cellular radio
  - Microwave and satellite communication system

Advantages of FM over AM:

- Freedom from interference: all natural and external noise consist of amplitude variations, thus receiver usually cannot distinguish between amplitude of noise or desired signal. AM is noisy than FM.
- Operate in very high frequency band (VHF): 88MHz-108MHz
- Can transmit musical programs with higher degree of fidelity.

Disadvantages of FM & PM:

- Angle modulation requires a transmission bandwidth much larger than the message signal bandwidth.

- Angle modulation requires more complex and expensive circuits than AM.

Basics of Networks

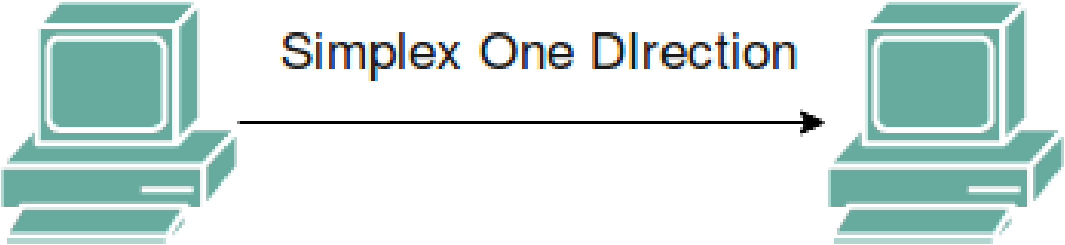
What is a Network?

- A network is **a collection of computers, servers, mainframes, network devices, peripherals, or other devices connected to one another to allow the sharing of data.**

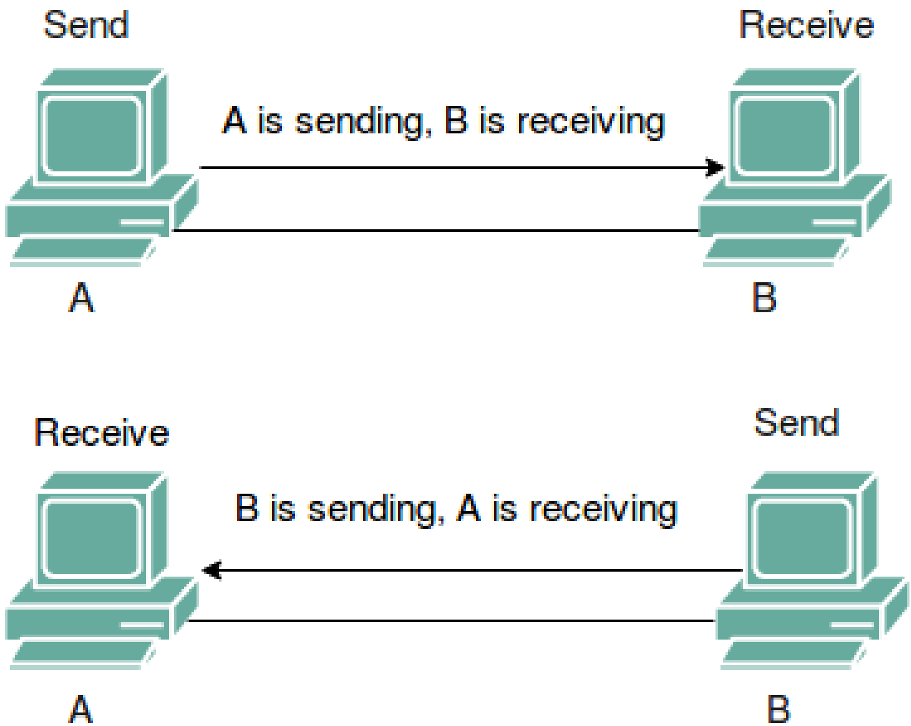
- An excellent example of a network is the Internet, which connects millions of people all over the world.

Types of transmission modes

- **Simplex**
  - 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.



- **Half-Duplex**
  - **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. e.g. Walki-talkie
  - 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.

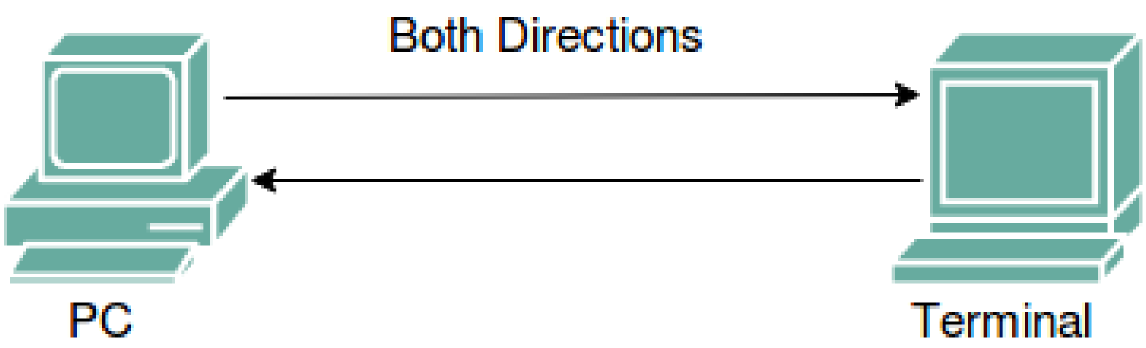


- **Full Duplex**
  - **both stations can transmit and receive simultaneously.**

  - E.g. telephone network. When two people are communicating by a telephone line, both can talk and listen at the same time.

  - The channel is being shared by both the stations. This sharing can occur in two ways:
    - Either the link must contain two physically separate transmission paths, one for sending and other for receiving.

    - Or the capacity is divided between signals travelling in both directions.



Network Topology

- **Network Topology is a physical layout of the computer network and it defines how the computers, devices, cables etc are connected to each other.**

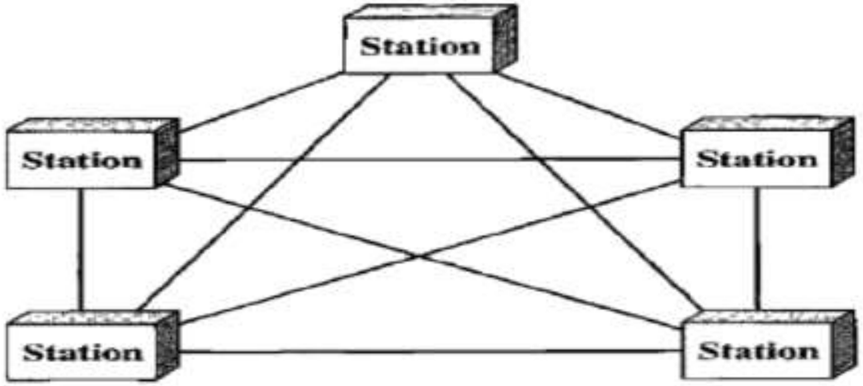
- There are four basic topologies possible:

  - mesh, star, bus, and ring

Mesh Topology

- **Every device has a dedicated point-to-point link to every other device.** The term dedicated means that the link carries traffic only between the two devices it connects.

- For n number of nodes it requires (n-1) physical links.

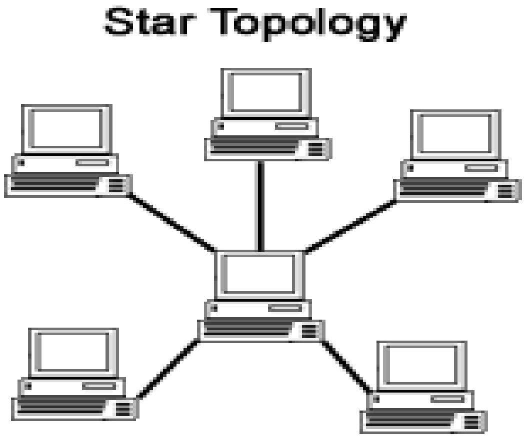


Star Topology

- **Each device has a dedicated point-to-point link only to a central controller, usually called a hub.**

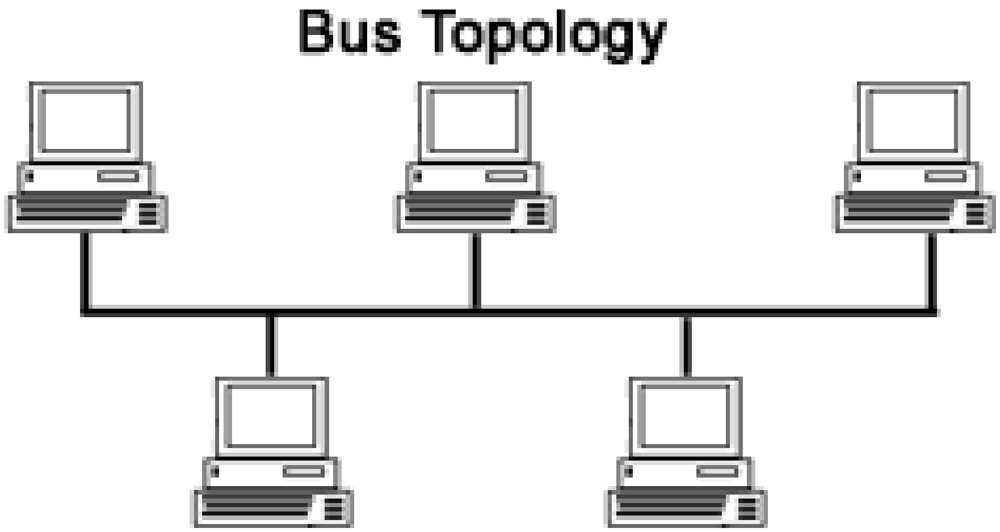
- The devices are not directly linked to one another. Unlike a mesh topology, a star topology does not allow direct traffic between devices.

- The controller acts as an exchange: If one device wants to send data to another, it sends the data to the controller, which then relays the data to the other connected device.



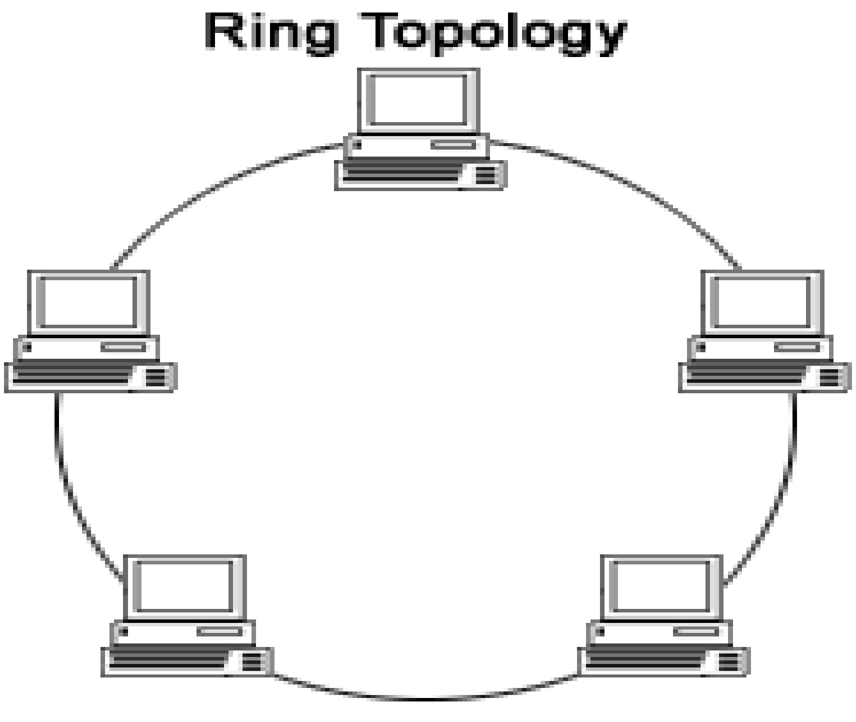
Bus Topology

- The preceding examples all describe point-to-point connections. **A bus topology, on the other hand, is multipoint. One long cable acts as a backbone to link all the devices in a network.**



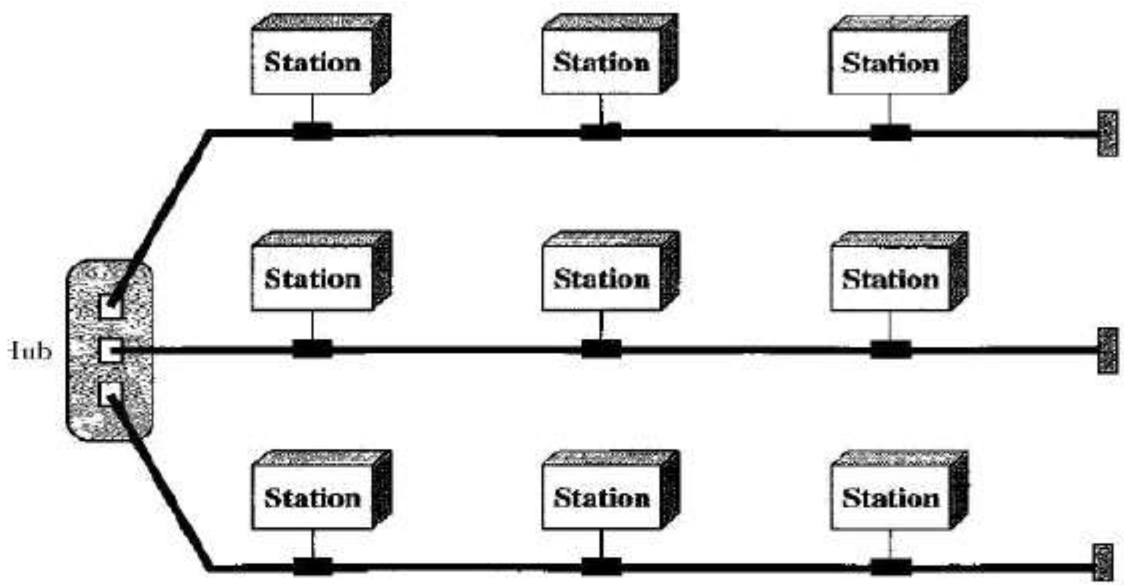
Ring topology

- **Each device has a dedicated point-to-point connection with only the two devices on either side of it.**
- A signal is passed along the ring in one direction, from device to device, until it reaches its destination.



Hybrid Topology

- A network can be hybrid. For example, we can have a main star topology with each branch connecting several stations in a bus topology.



Types of Networks

- Two primary categories: **Local area networks (LAN) and wide-area networks (WAN).**

- The category into which a network falls is determined by its size.
- A LAN normally covers an area less than 2 miles; a WAN can be worldwide.
- Networks of a size in between are normally referred to as Metropolitan area networks (MAN) and span tens of miles.

Local area network (LAN)

- LAN is **usually privately owned and links the devices in a single office, building, or campus.**

- LANs are designed to allow resources to be shared between personal computers or workstations.

- The resources to be shared can include hardware (e.g., a printer), software (e.g., an application program), or data.

- A common example of a LAN, found in many business environments, links a workgroup of task-related computers, for example, engineering workstations or accounting PCs.

Wide area network (WAN)

- WAN **provides long-distance transmission of data, image, audio, and video information over large geographic areas that may comprise a country, a continent, or even the whole world.**

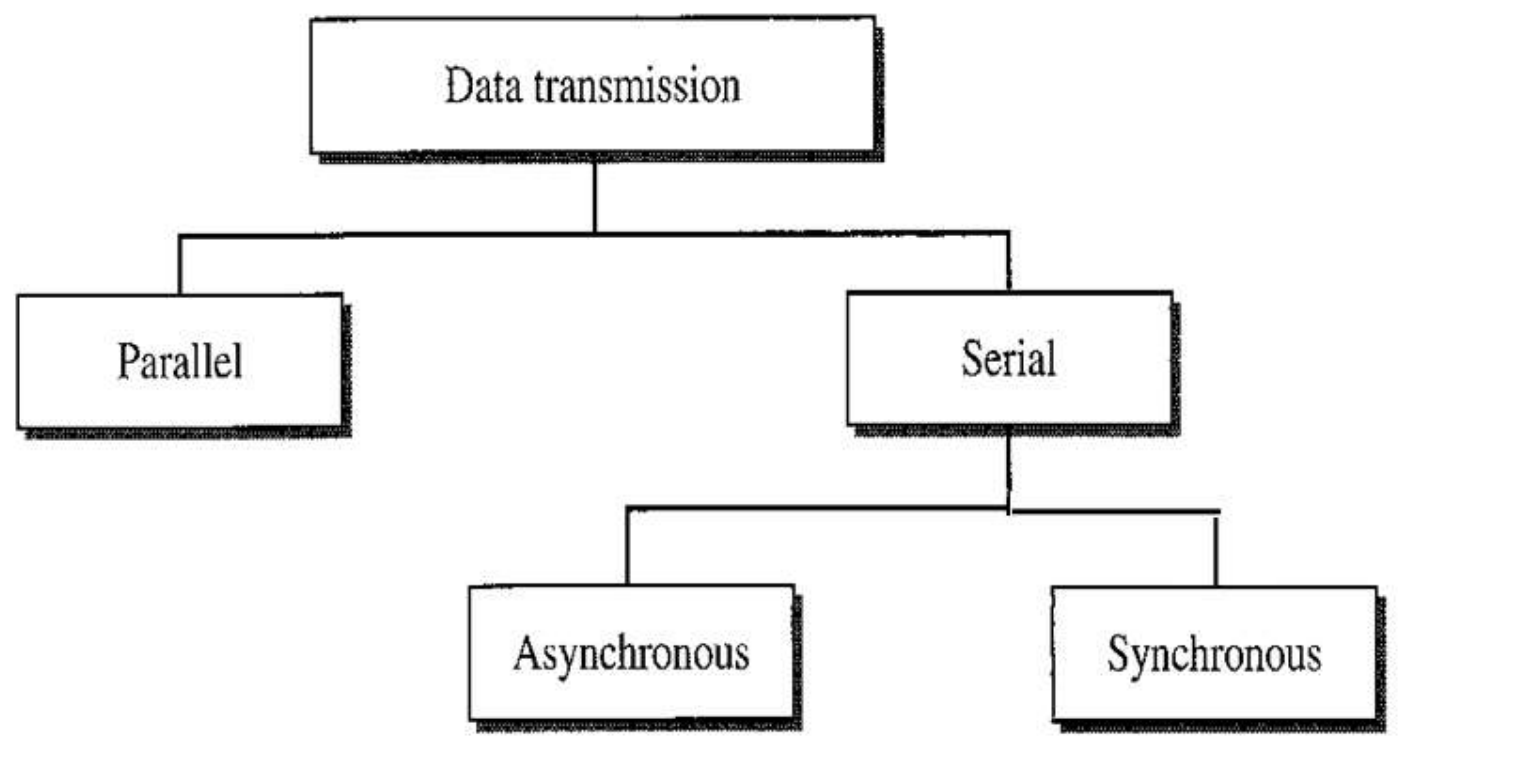
- A metropolitan area network (MAN) is a network with a size between a LAN and a WAN.

- It normally covers the area inside a town or a city. It is designed for customers who need a high-speed connectivity, normally to the Internet, and have endpoints spread over a city or part of city.

- A good example of a MAN is the part of the telephone company network that can provide a high-speed DSL line to the customer.

Transmission Modes

- The **transmission of binary data across a link** can be accomplished in either parallel or serial mode .

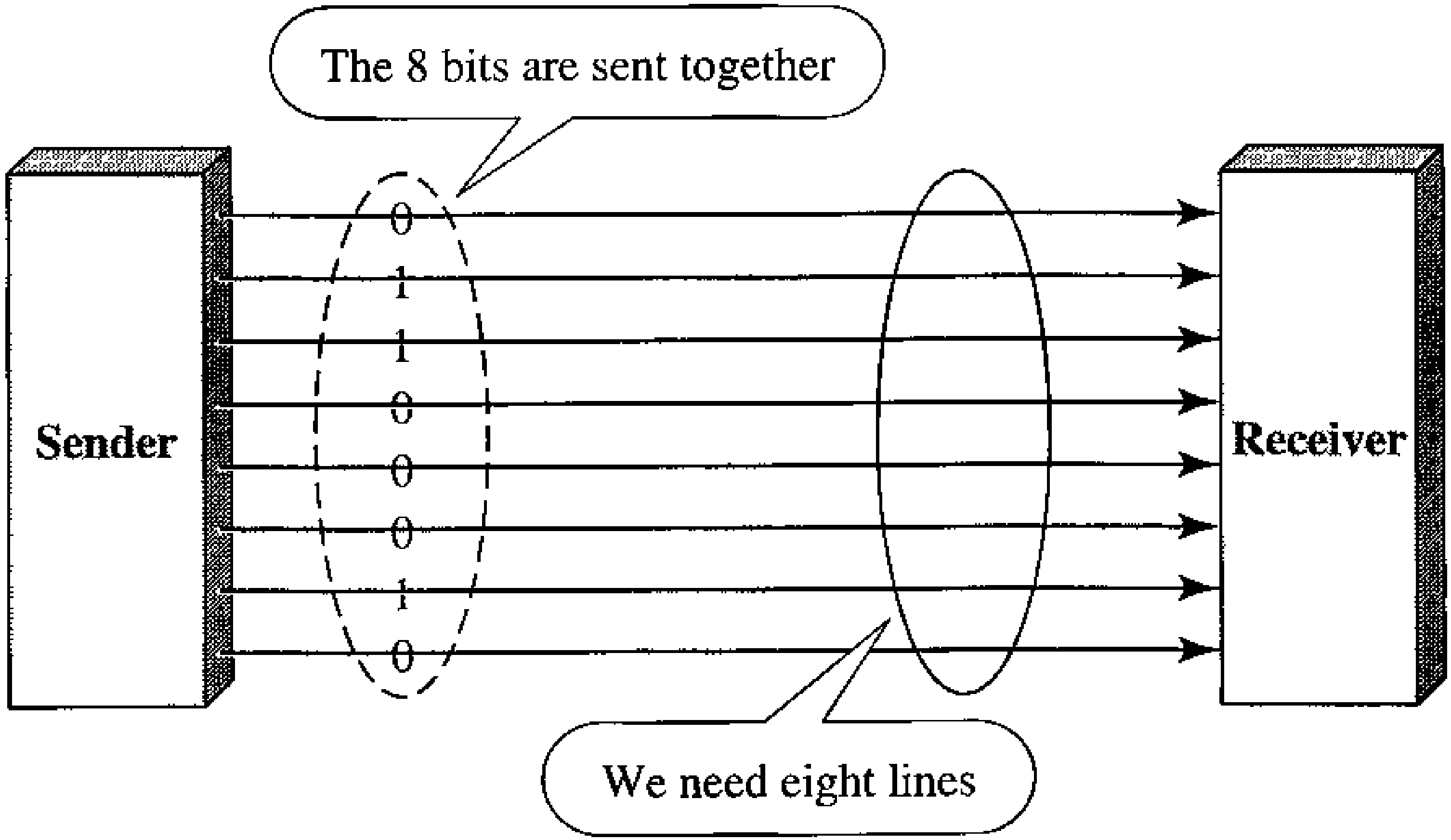


Parallel Transmission

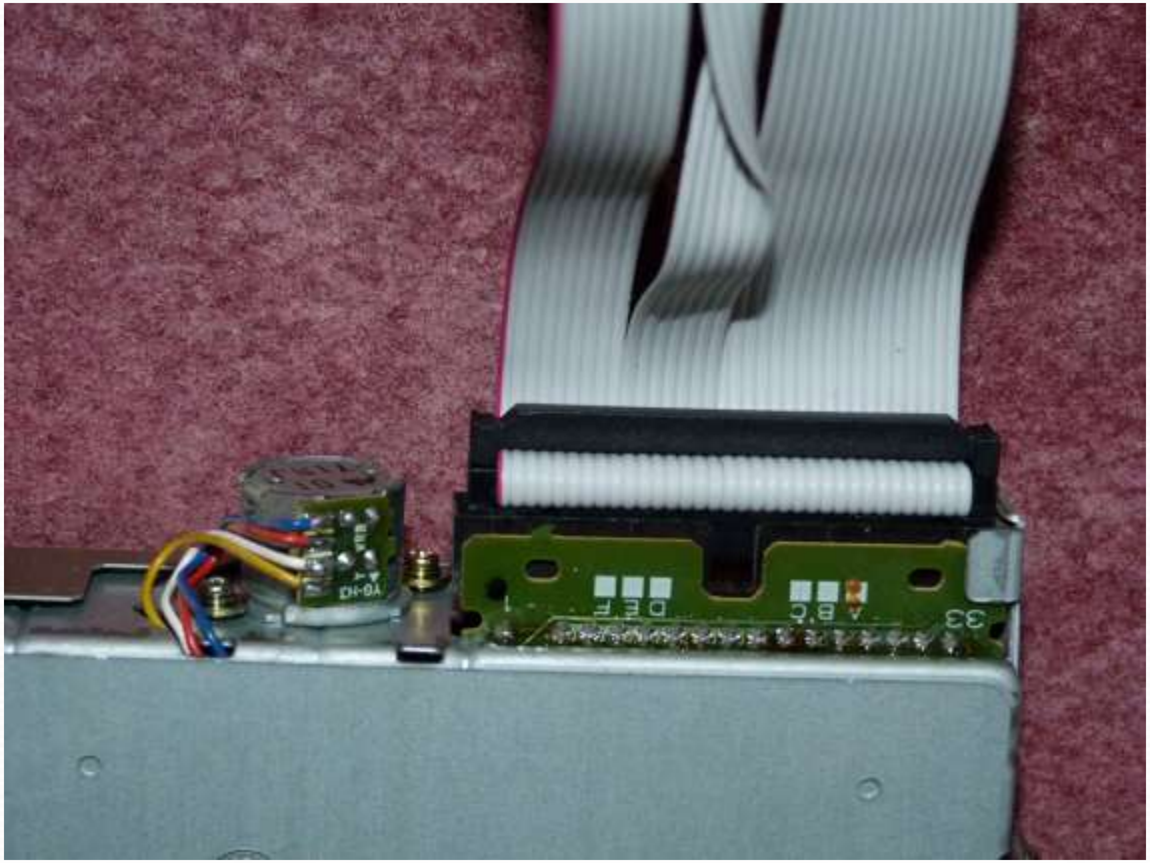
- In parallel transmission **n bits are transferred simultaneously,** hence we have to process each bit separately.
- Use of n wires to send n bits at one time

- The advantage is high transfer speed
- Disadvantage is cost
- Limited to short distances

Parallel Transmission



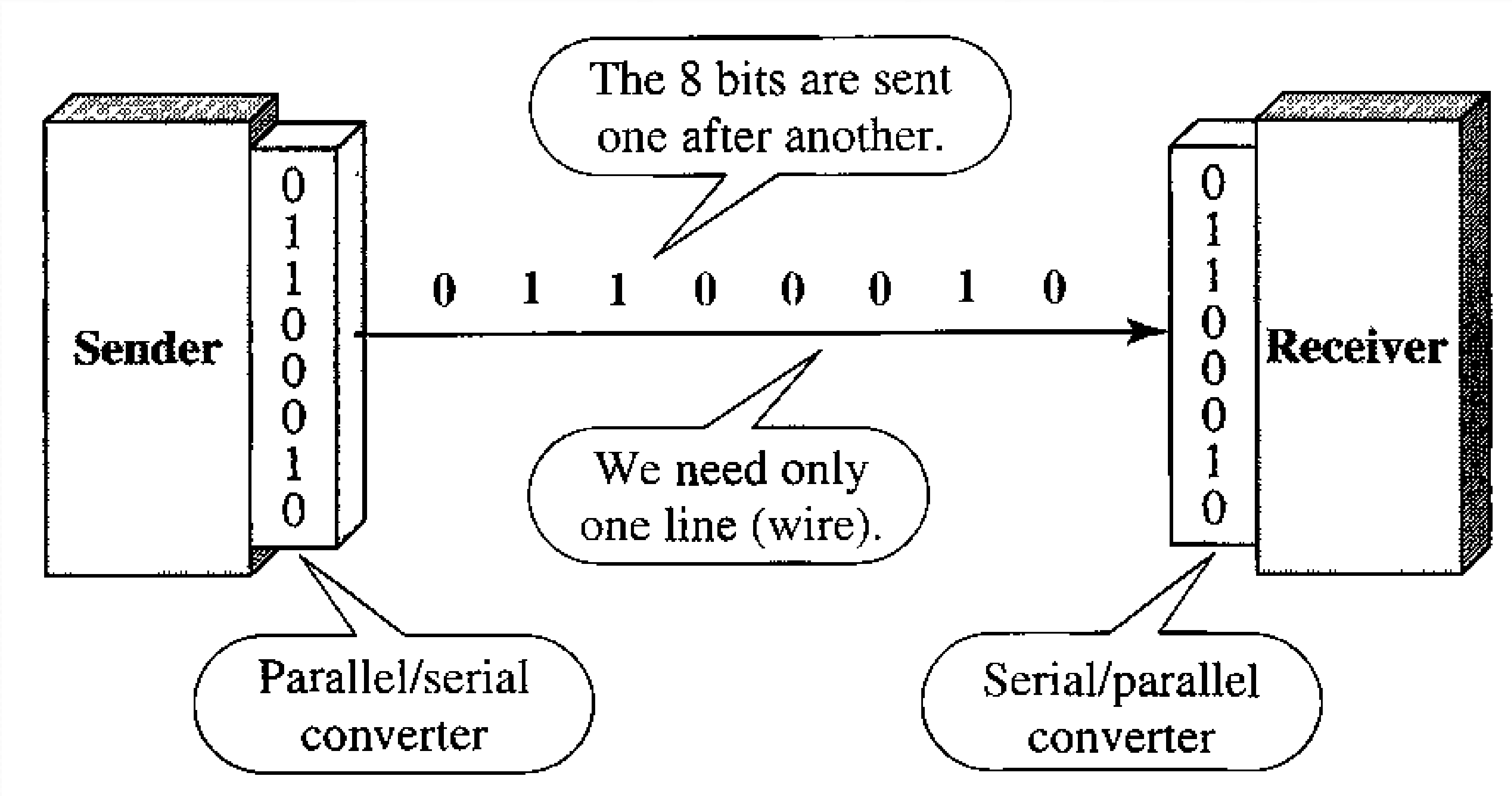
Parallel Transmission Mode



Serial Transmission

- 1 bit is sent with each clock tick, **data are transmitted sequentially.**
- Need only one communication channel
- Reduce cost
- Since communication within devices is parallel, **conversion devices** are required at the interface between the sender and the line and between the line and the receiver

Serial Transmission Mode



Asynchronous Serial transmission

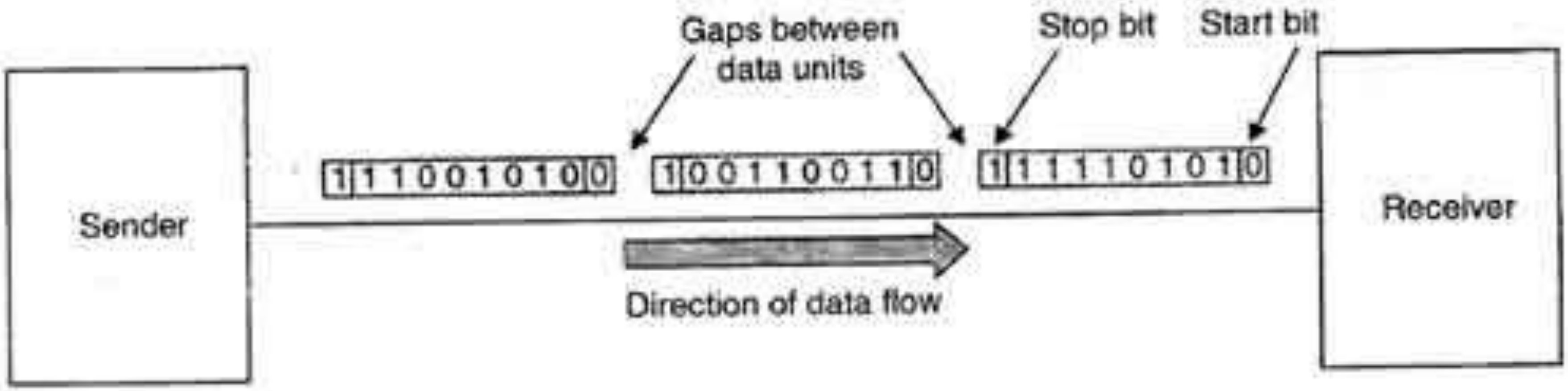
- In **asynchronous transmission** timing of signal is unimportant. Instead, information is received and translated by agreed upon patterns.

- Patterns are based on grouping the bit stream into bytes.

- At byte level, the sender and receiver do not have to synchronize but the bits are still synchronized; their durations are the same.

- Disadvantage is slower
- Advantage is cheap .
- Example : Connection of a keyboard to a computer, UART

Asynchronous Serial Transmission Mode



Asynchronous Transmission

Synchronous Serial transmission

- In **synchronous transmission,** data are transmitted as an unbroken string of 1s and 0s, and the receiver separates that string into the bytes.

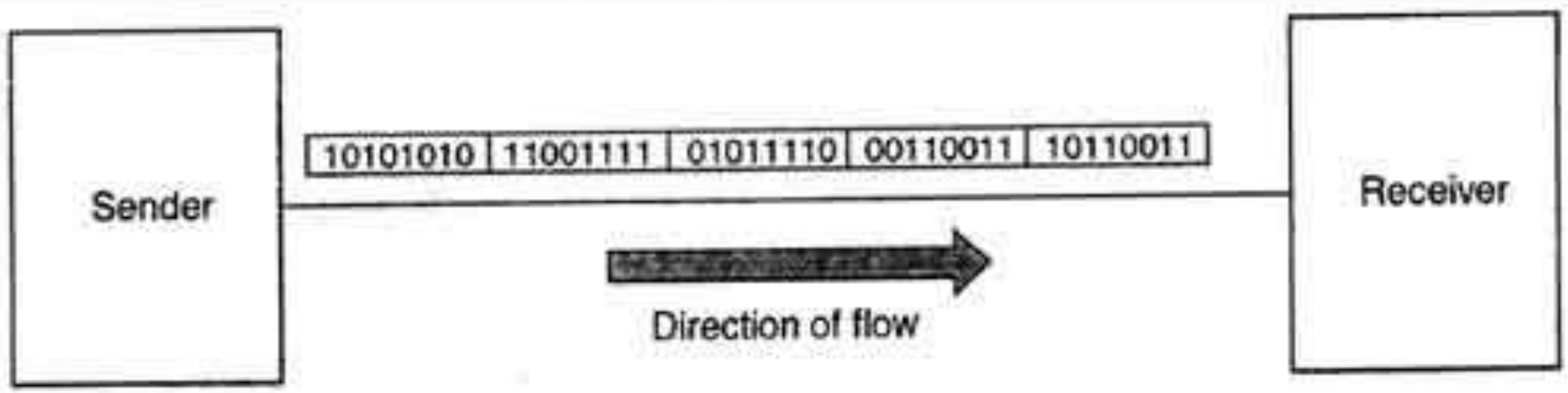
- The accuracy of the received information is completely dependent on the ability of the receiving device to keep an accurate count of bits as they come in.

- **So timing becomes very important in this transmission.**

- Advantage is speed
- Useful for high speed applications such as the transmission of data from one PC to another.

e.g.USB, Ethernet.

Synchronous Serial Transmission Mode



Synchronous Transmission

Bit Rate

- **The speed of the data is expressed in bits per second (bits/s or bps).** The data rate R is a function of the duration of the bit or bit time (T_B)

$$R = 1/T_B$$

- In digital telecommunication, the bit rate is the number of bits that pass a given point in a telecommunication network in a given amount of time, usually a second.
- The term *bit rate* is a synonym for data transfer rate(or simply *data rate*)

Baud rate

- The output from a binary source can be combined in **groups of bits, each group being identified by a separate symbol.**

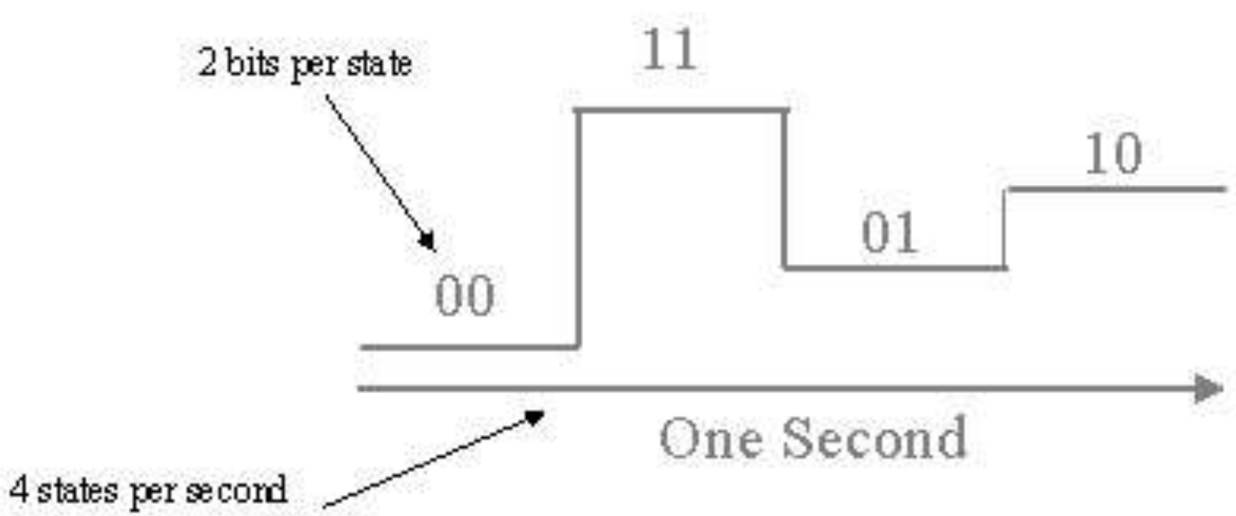
- Baud rate refers to the **number of symbol changes that occur per second.**

- **Baud rate = Bit rate/No. of bits per symbol**

- Digital signal can have more than two levels. If a signal have L levels, each level needs $\log_2 L$ bits.

Baud rate

– Therefore the Bit rate = 8 bits per second
– Bit rate = x2 Baud rate in this example



Problem on Baud rate

- An analog signal has a bit rate of 8000 bps and a baud rate of 1000 baud. How many data elements are carried by each signal element? How many signal elements do we need?

SNR, Channel Bandwidth and Rate of Communication

- For noisy channel ,Shannon capacity

$$\mathbf{C = Blog_2 (1+SNR)\ bps}$$

- This expression represents the maximum possible rate of information transmission through a given channel or system. The maximum rate we can transmit information is set by the bandwidth, the signal level, and the noise level.

- Channel capacity is the maximum no. of binary symbols that can be transmitted per second with a probability of error arbitrarily zero.

Problem on Rate of Communication

- Assume that $SNR_{dB} = 36$ and the channel bandwidth is 2 MHz. Calculate theoretical channel capacity.

Network Model

- **A method of describing and analyzing data communication networks by breaking the entire set of communication process into a number of layers.**

- **Each layer has a specific function. It provides services to an adjacent layer.**

The OSI Model

- International standard organization (ISO) established a committee in 1977 to develop an architecture for systems communication.

- **Open System Interconnection (OSI) reference model** is the result of this effort.

- This model allows any two different systems to communicate regardless of their underlying architecture.

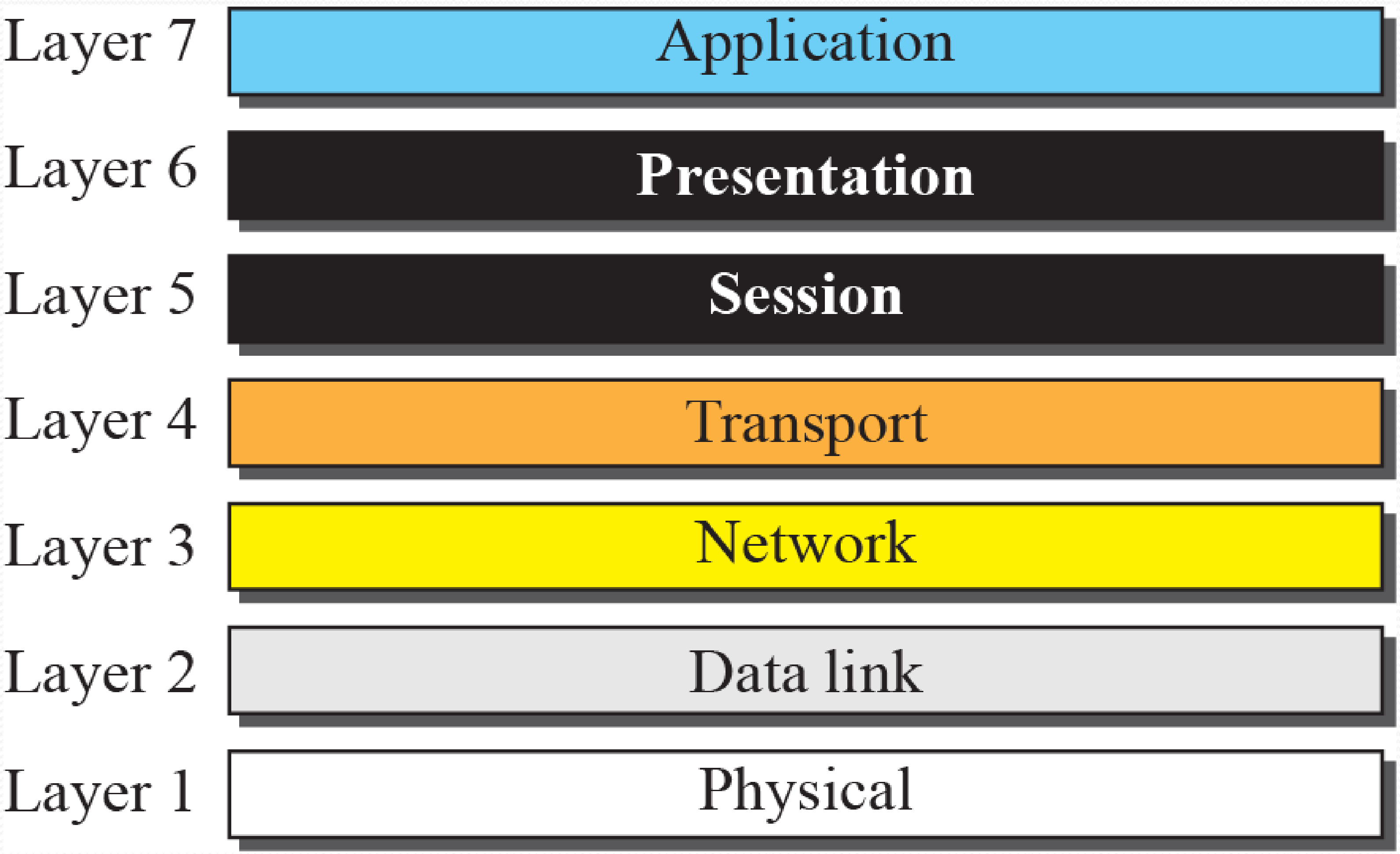
Cntd ..

- The OSI model describes how data flows from one computer, through a network to another computer.

- The OSI model is <u>not a protocol; it is a model</u> for understanding and designing a network architecture that is flexible and robust.

- The OSI model consists of seven separate but related layers, each of which defines a part of the process of moving information across a network.

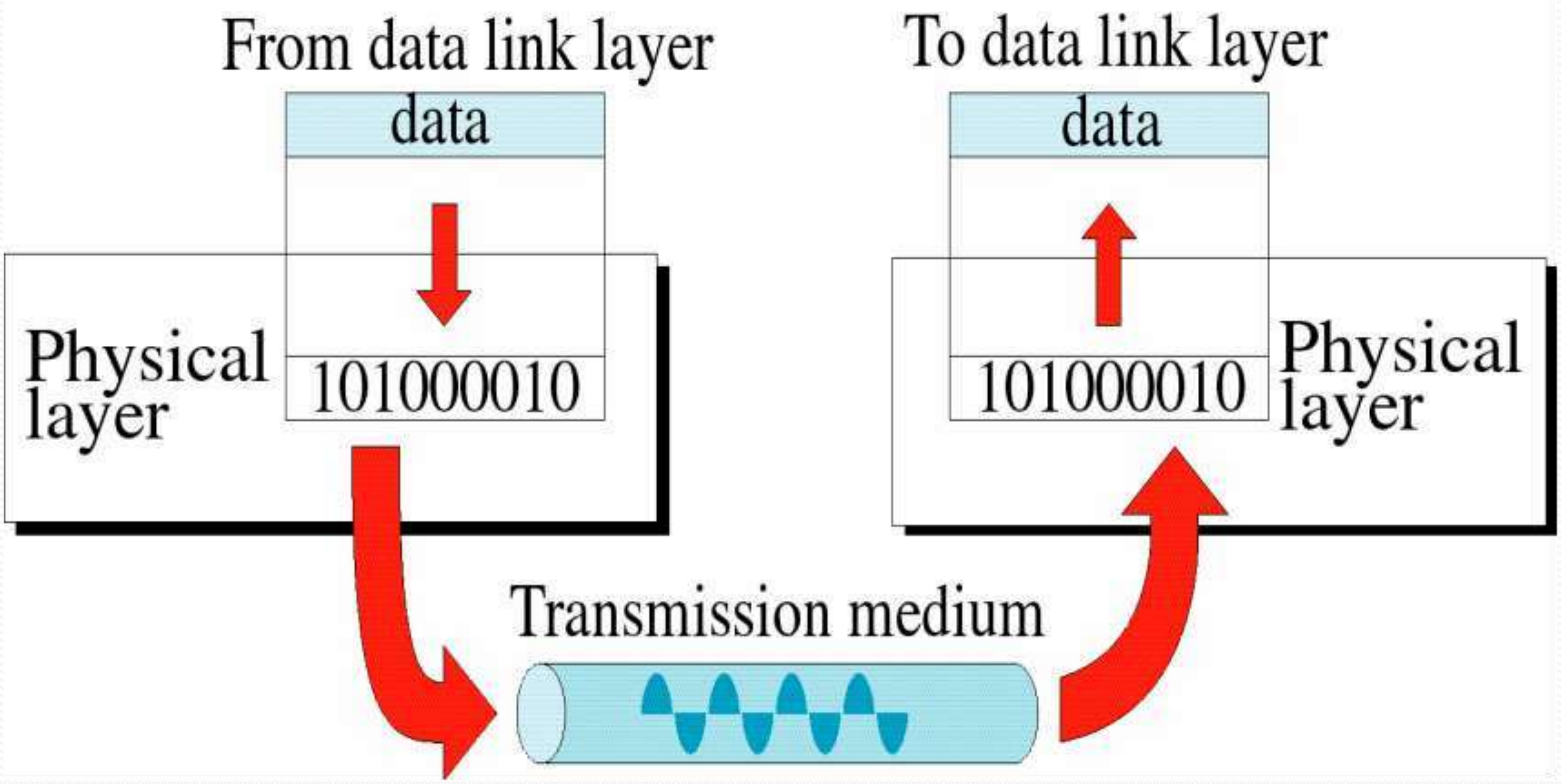
Seven layers of the OSI model



Physical Layer

- Physical layer is the bottom(layer 1) of OSI model.
- **It is responsible for the actual physica connection between the devices.**
- The physical layer is responsible for movements of individual bits from one node to next.

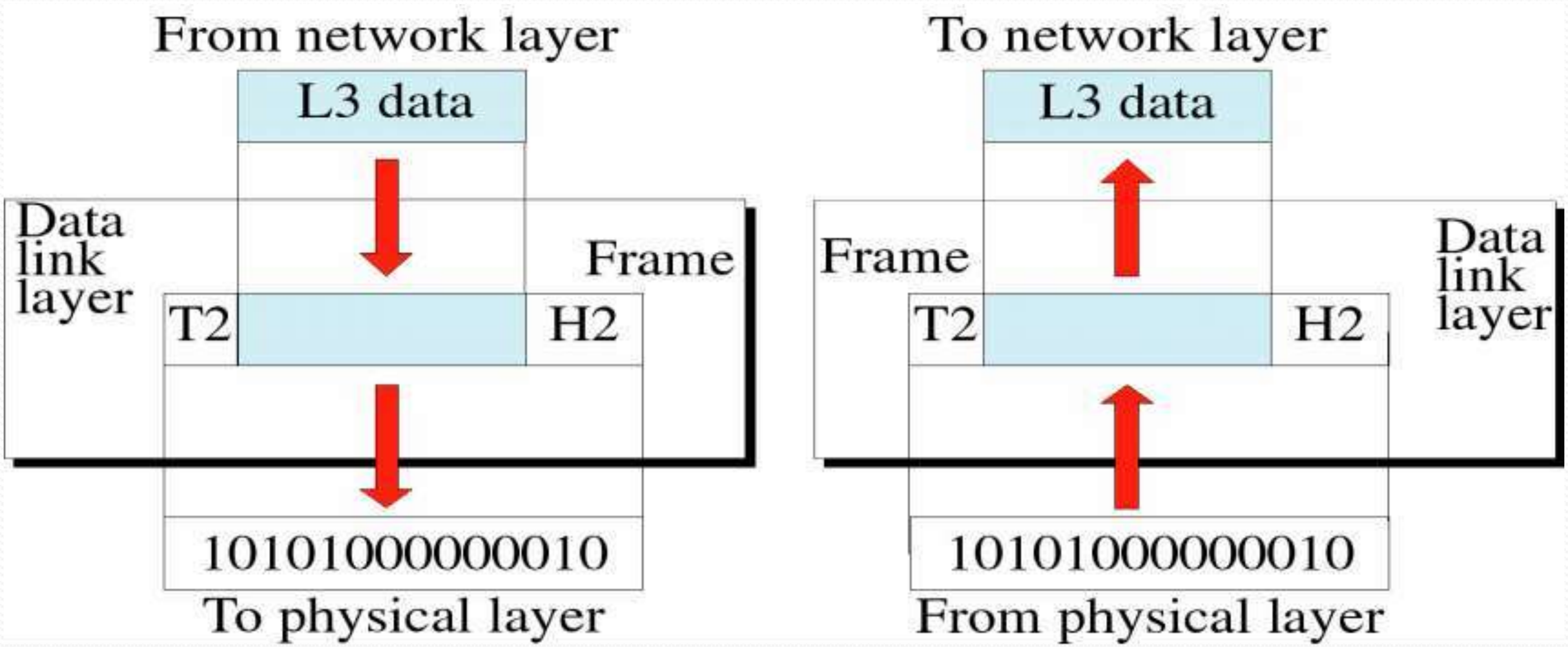
Physical layer



Functions of Physical Layer:

- Convert bits to signals
- Bit synchronization
- Manage physical connection
- Bit rate control
- Line configuration
- Physical topology
- Transmission mode
- Multiplexing
- Switching

Data Link Layer

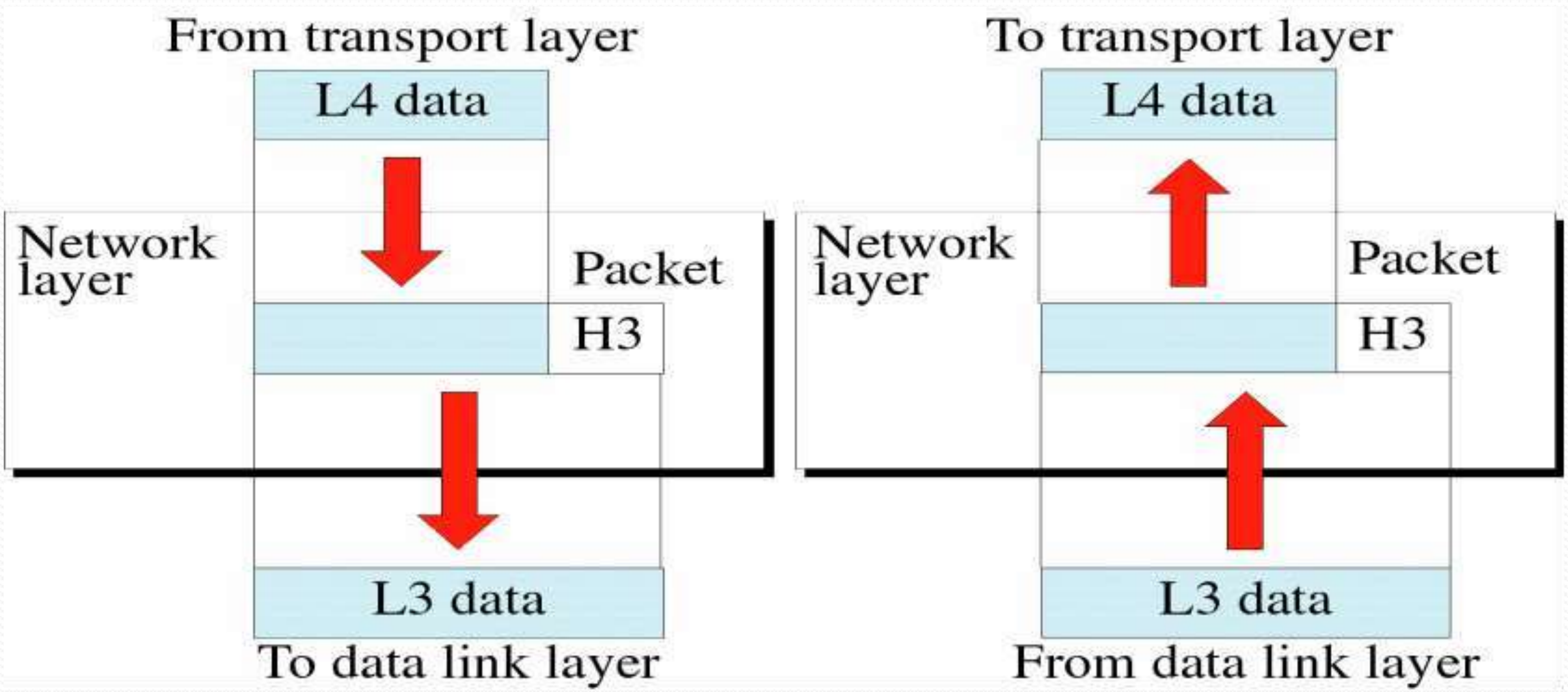


- **The data link layer is responsible for moving frames from one node to the next.**

Functions of Data Link Layer

- Framing:- divides the data from N/W layer into frames.
- Physical Addressing:- Add a header to the frame to define the physical address of the source and the destination machines.
- Flow Control:- It is the traffic regulatory mechanism implemented by Data Link layer that prevents the fast sender from drowning the slow receiver.
- Error Control:- It provides the mechanism of error control in which it detects and retransmits damaged or lost frames.
- Feedback:- after transmitting the frames, the system waits for the feedback.

Network Layer



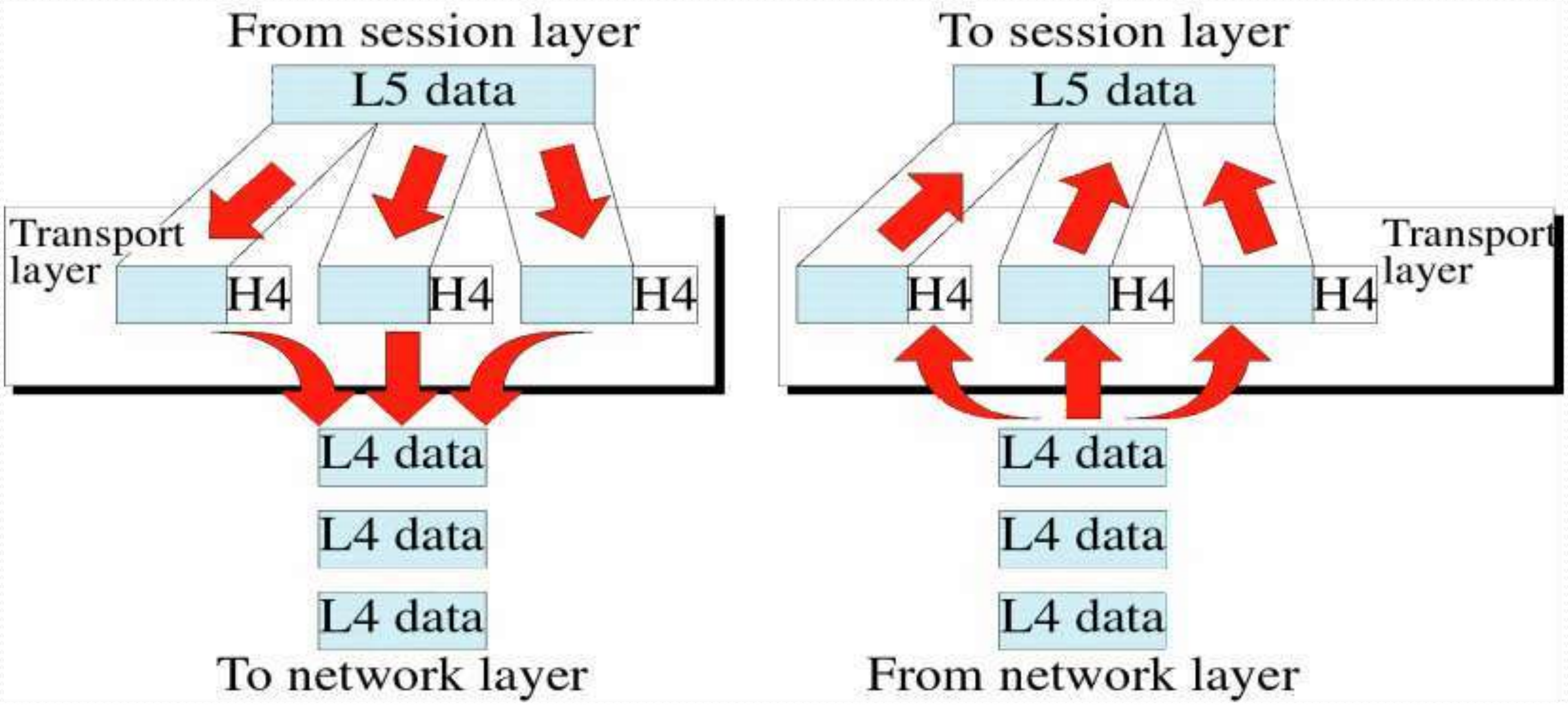
Functions of Network layer

- **It is responsible for the source to destination delivery of a packets across multiple networks.**

- Routing:- Provide mechanism to transmit data over independent networks that are linked together.

- Logical addressing:- Adds Logical addresses of sender and Receiver.

Transport Layer:



- **It is responsible for source process to destination process delivery of entire message.**

Cntd …

- Transport layer provides two types of services:

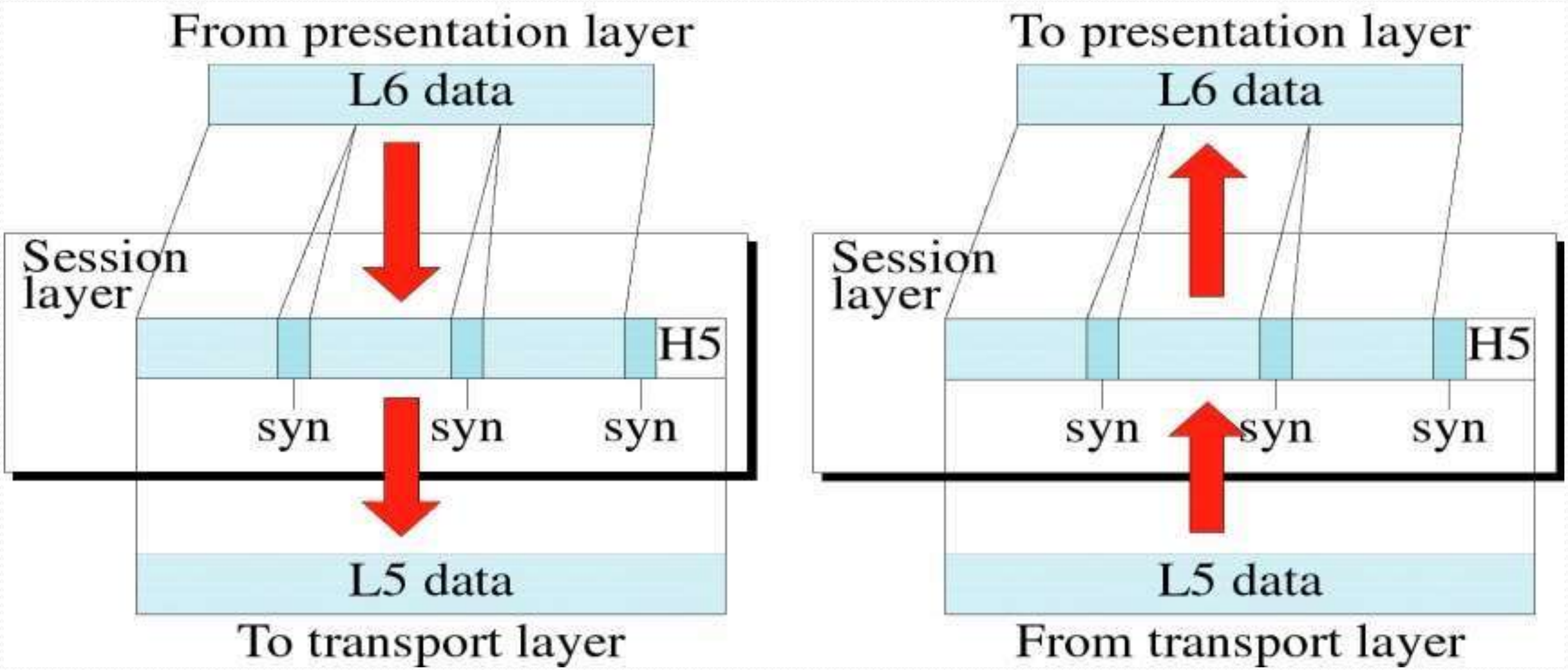
1) Connection Oriented Transmission: In this type of transmission the receiving device sends an acknowledgment back to the source after a packet or group of packet is received.

2) Connectionless Transmission: In this type of transmission the receiver does not acknowledge receipt of a packet.

Functions of Transport Layer:

- Segmentation and Reassembly: Divide the message received from Session layer into Segments and number them to make a sequence for reassembly at the receiving side.
- Service point addressing: Transport layer makes sure that the message is delivered to the correct process on destination machine.
- Error Control: Make sure that the entire message arrives without errors else retransmit.
- Flow Control: Transport layer makes sure that the sender

Session Layer



- It is responsible for beginning, maintaining & ending the communication between two devices, which is called session.

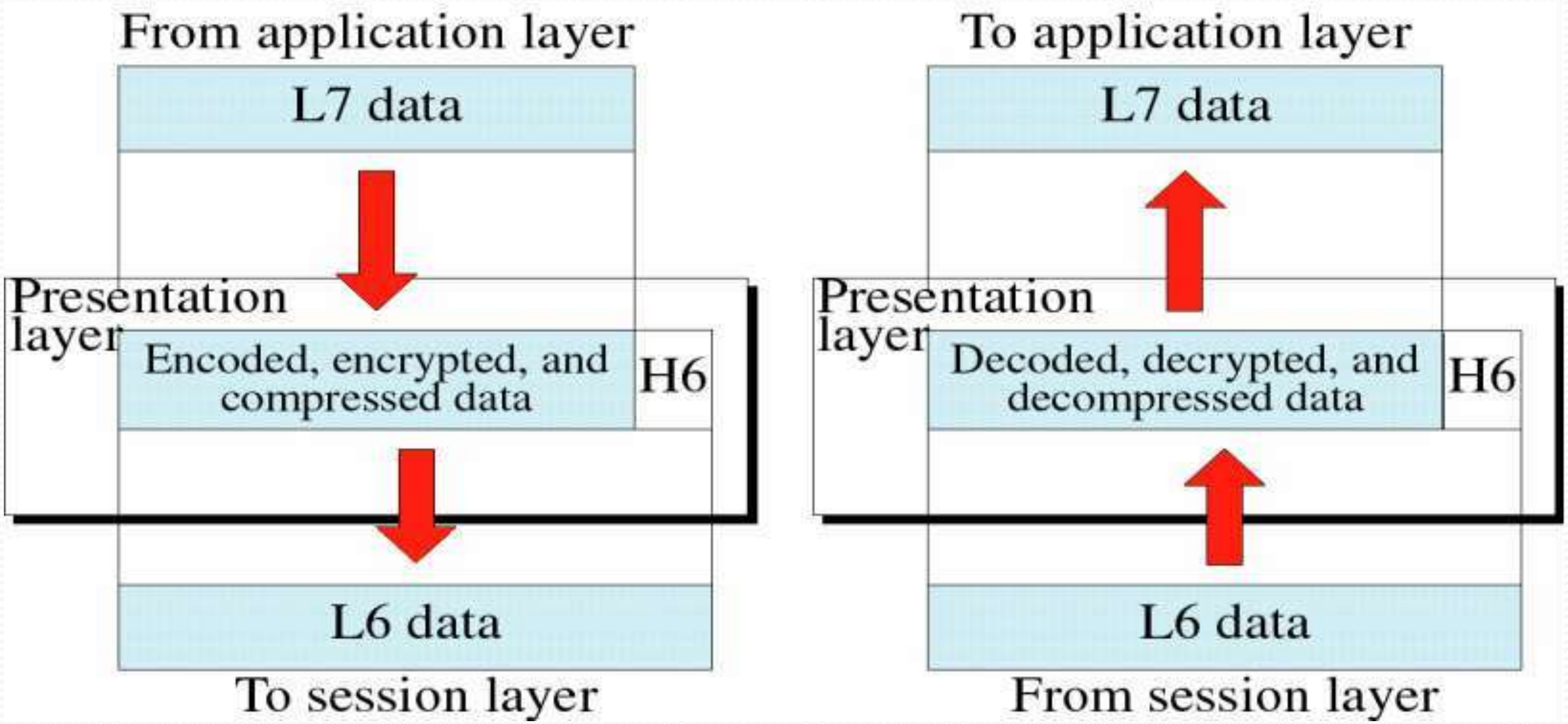
Functions of Session Layer:

- Establishment, maintaining and ending a session:
  - Sends SYN packet – establish request
  - Receives ACK & SYN- established
  - To end – Sender sends ACK

- Dialog Control: The session layer allows two systems to enter into a dialog.

- Synchronization: Allows a process to add checkpoints to a stream of data.

Presentation Layer



- **This layer is concerned with the syntax and semantics of the information exchanged between two systems.**

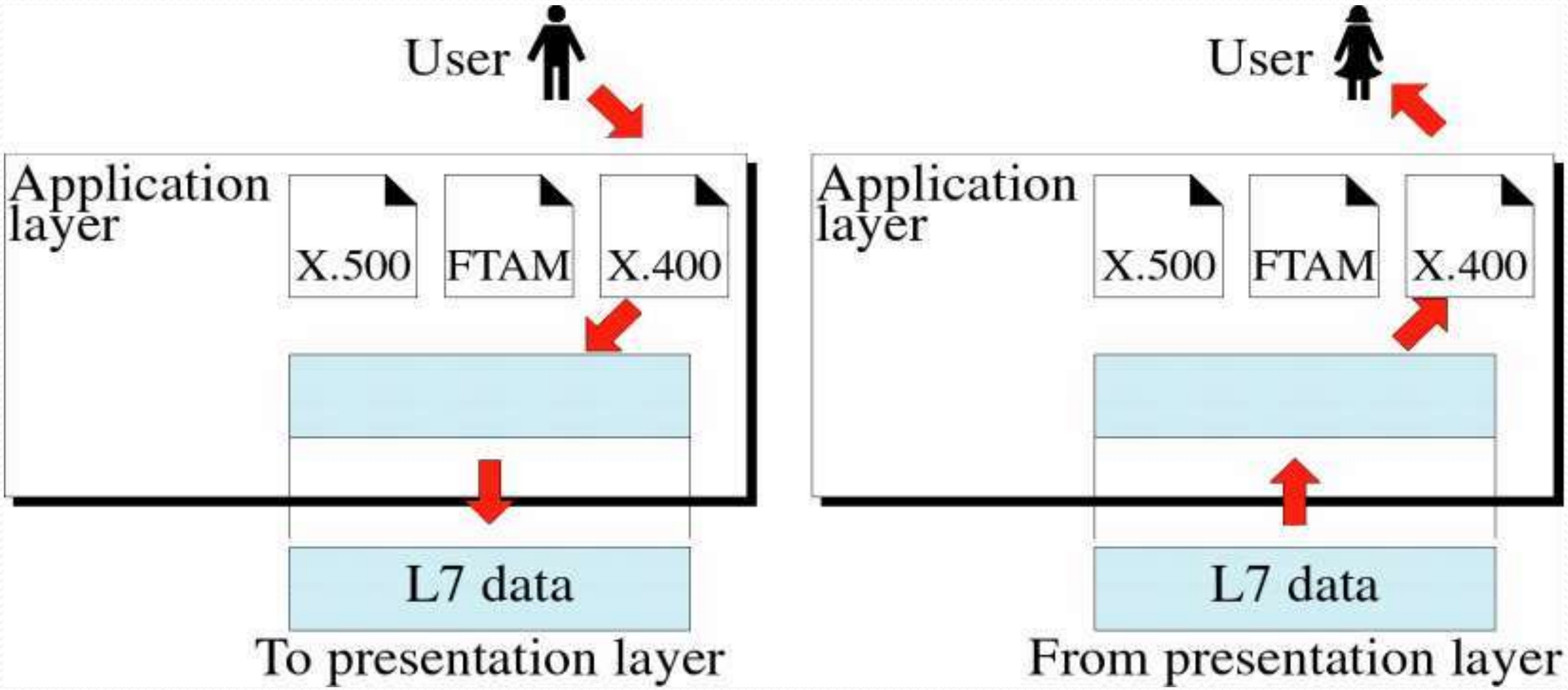
Functions of Presentation Layer

- Data Translation: Encoding and Decoding Sender to Common format on Sending side Common to Receiving format on Receiver side

- Data Encryption: For security and privacy purpose.

- Data Compression: Data compression reduces the number of bits contained in the information.

Application Layer



- **Provides User interfaces and support for Services, like e- mail, file transfer.**

Functions of Application Layer

- Network Virtual terminal: It allows a user to log on to a remote host.

- File Transfer Access, and Management: This application allows a user to access files in a remote host.

- Mail Services: This application provides various e-mail services.

- Directory Services: This application provides the distributed database sources and access for global information about various objects and services.

Network Protocols

- **IP (Internet Protocol):** the principal communications protocol to exchange the data across networks.
- **TELNET(Terminal Network):** two-way communication protocol which allows connecting to a remote machine and run applications on it. (remote login)
- **FTP(File Transfer Protocol):** For transfer of file from one system to another.
- **SMTP(Simple Mail Transport Protocol):** To transport electronic mail between a source and destination, directed via a route.
- **HTTP(Hyper Text Transfer Protocol):** For fetching web
- pages on world wide web.