WIRELESS AND MOBILE COMMUNICATION

PREREQUISITES

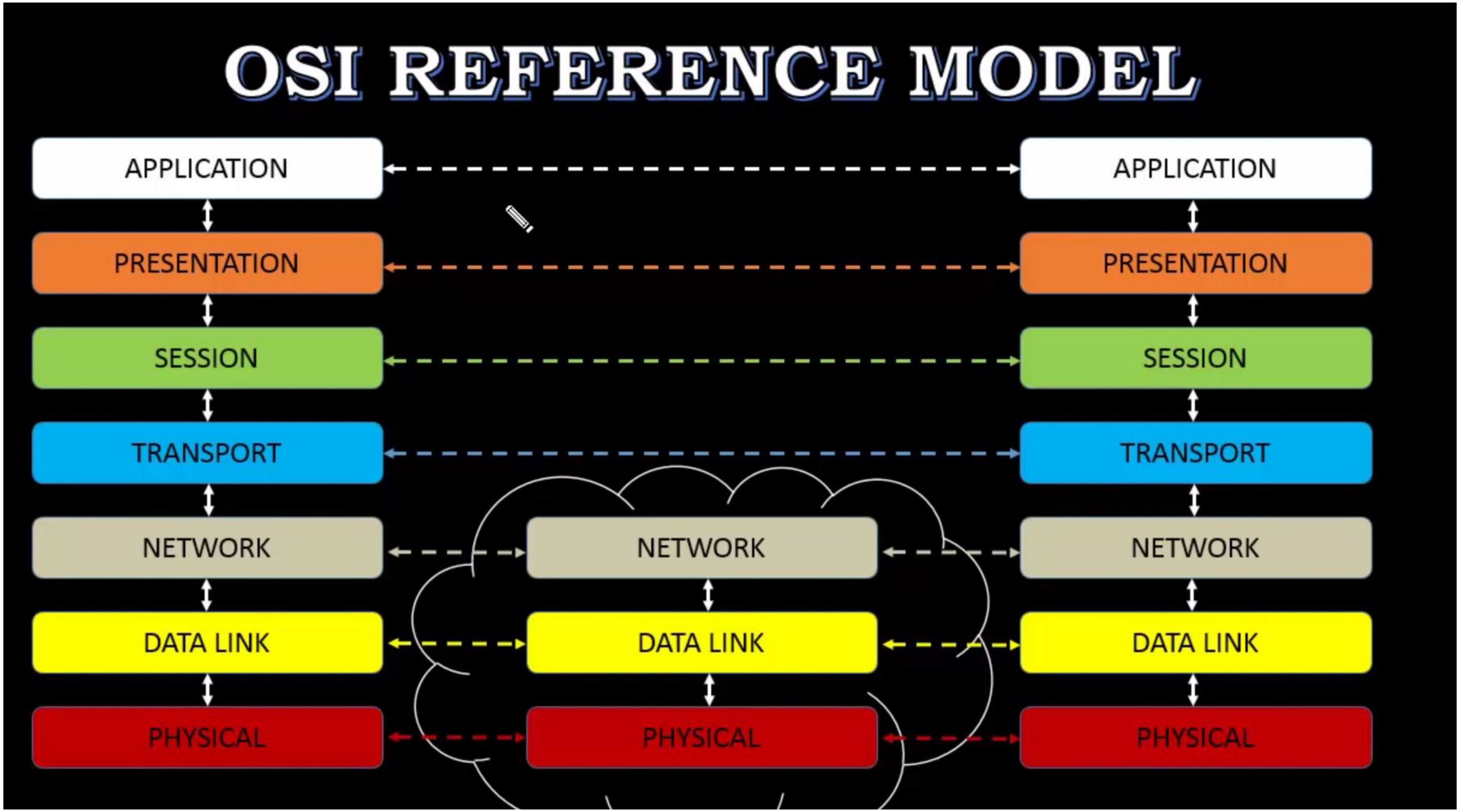
- What is Network?

  - Communication between different systems.
  - Purpose is Information Sharing.

- What is Network protocol?

  - Network protocols are formal standards and policies comprised of rules, procedures and formats that define communication between two or more devices over a network.

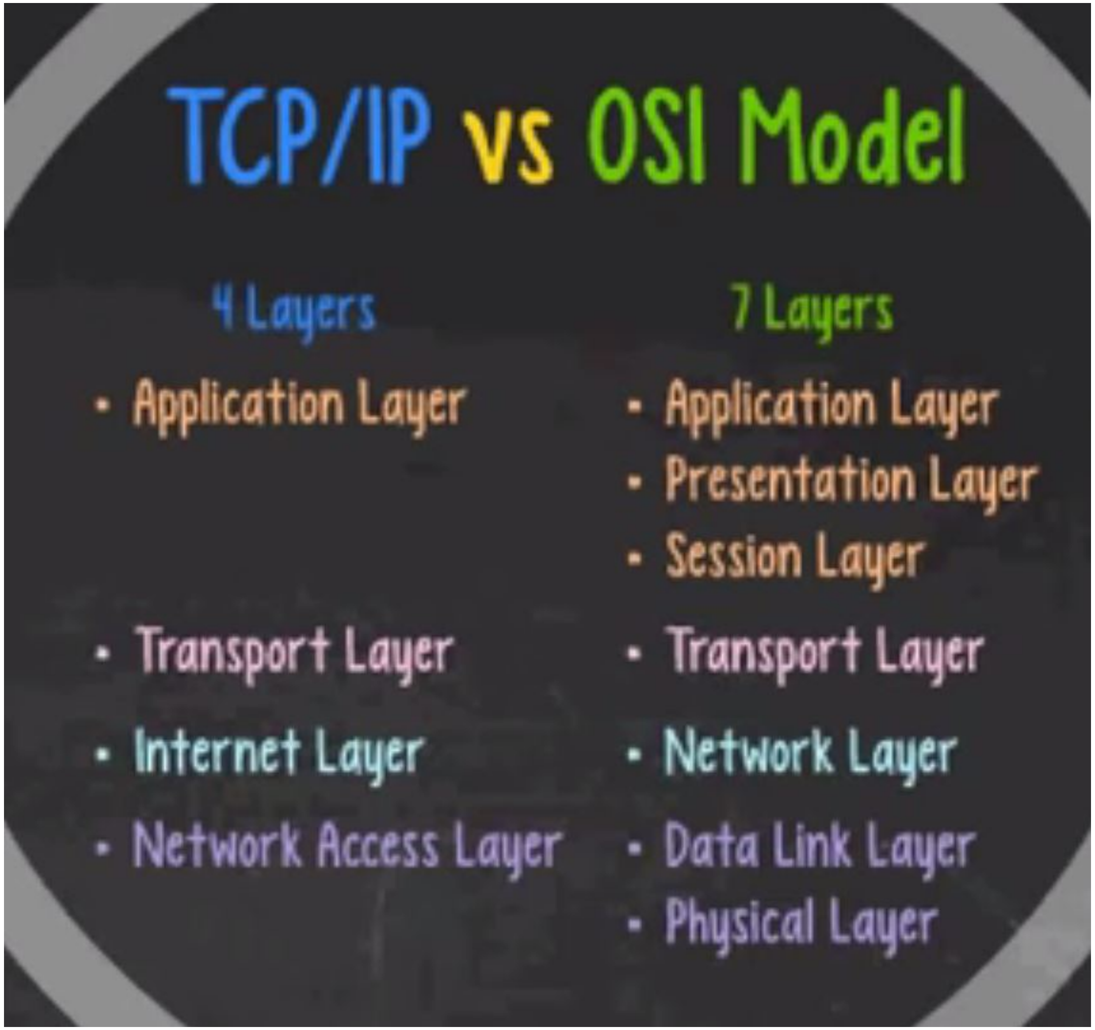
OSI REFERENCE MODEL



HOW THE NETWORK WORKS

Layers	PDU	Functions	Protocols
7. Application Layer	Data	Human-Machine Interface	HTTP,FTP,SMTP,SNMP,DNS, TELNET,DHCP
6. Presentation Layer		Encryption, Decryption, Representation of Data Format	SSL, TLS
5. Session Layer		Establishment, Maintain, Termination of Sessions	PPTP, SIP, SAP, NetBIOS
4. Transport Layer	Segment	Segmentation, Acknowledgement, Sequencing, Duplicate Detection.	TCP, UDP
3. Network Layer	Packet	Addressing & Routing	IPV4, IPV6, IPSec, ICMP, IGP, EGP
2. Data-link Layer	Frames	Error Detection, Flow control	ATM, SLIP, Frame Relay, PPP
1. Physical Layer	Bits	Hardware means of sending & Receiving bits streams on a carrier	USB, Bluetooth,

TCP/IP



TCP/IP vs OSI Model
4 Layers
• Application Layer
• Transport Layer
• Internet Layer
• Network Access Layer
7 Layers
• Application Layer
• Presentation Layer
• Session Layer
• Transport Layer
• Network Layer
• Data Link Layer
• Physical Layer

Introduction

- In 1874 Marconi experiments to send signals using electromagnetic waves.

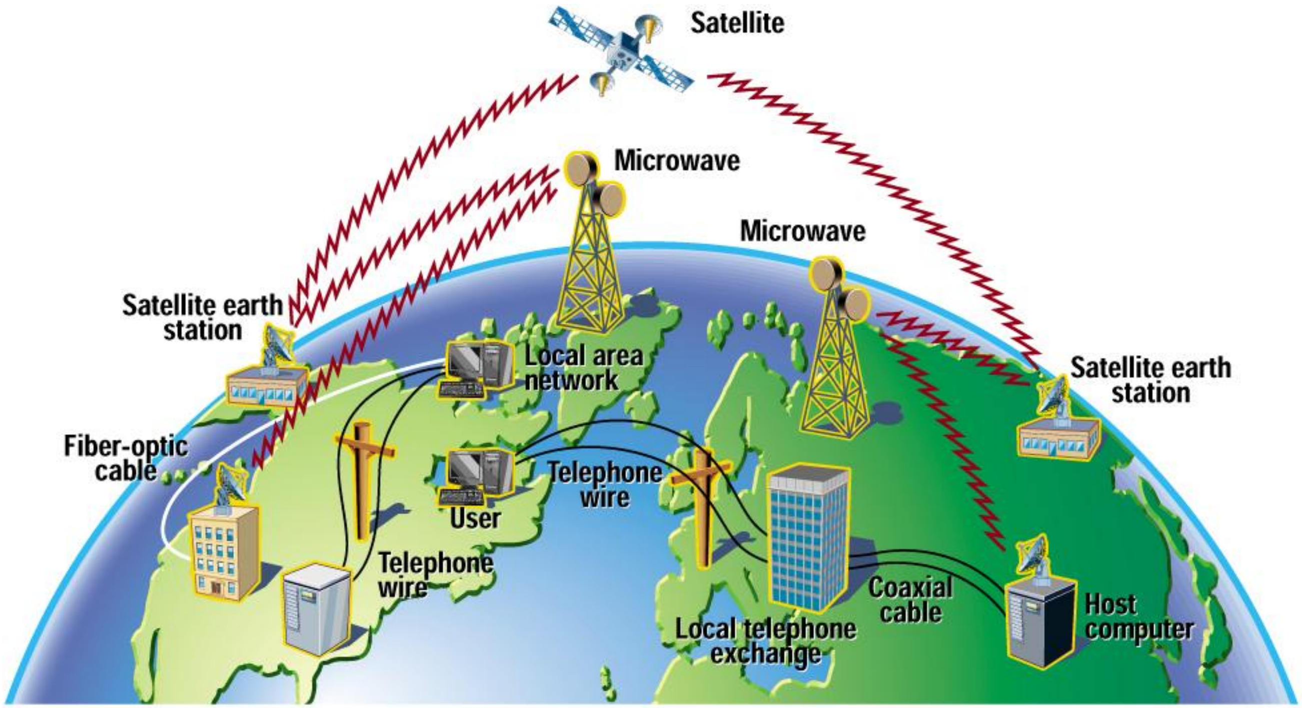
- The obstacle of radio transmission was overcame by sending signal for two distinct points.

- This paved the way for wireless telegraphy also known as radio communication (Radiated energy).

Introduction (cont.)

- In 1901 Marconi setup a transmitting station in England. It's setup was about 3,500km.
- This was due to the presence of the ionosphere, a layer above the earth.
- The ionosphere reflects electromagnetic waves which allow a radio signal to travel far distances.
- This is the fundamental to all long-distance wireless radio communication.

?What is Communication



- The process of sharing data, programs, and information between two or more systems.

Wireless And Mobile Communication

- Based on the nature of wireless transmission, Wireless communication systems may be classified into 3 types

  - Simplex

  - Half-duplex

  - Full-duplex

Simplex Communication

- Transmitters and receivers operate at the same frequency and communication.
- It is possible in only one direction from the transmitter to the receiver at any time.
- For example paging and messaging systems are simplex wireless system.

Half-duplex Communication

- It is two-way communication system. But a subscriber can only transmit or receive voice information at any given time.
- Here the same frequency is used for both transmission and reception, with a push-to-talk feature.
- For example walkie-talkie wireless communication are half-duplex system.

Full-duplex Communication

- It allow simultaneous radio transmission and reception between the calling and called subscribers of the system, either directly or Via a base station.
- They use separate frequency channels FDD or different time slots on a single radio channel TDD.
- An example of a full-duplex device is a telephone; the parties at both ends of a call can speak and be heard by the other party simultaneously.

Elements of Communication Systems

- Basic elements of a communication system:
  - **Sending and Receiving Devices** (computers or specialized communication devices).
  - **Communication Channel** (transmission medium) (physical wire or cable and wireless connection).
  - **Connection Devices** (communication devices): Act as an interface between the sending and receiving devices and the communication channel, they convert outgoing message into a form and format so that they can travel across the communication channel.
  - **Data Transmission specifications:** rules and procedures that coordinate the sending and receiving devices (how the message will be send through the communication channel)

Advantages and Disadvantages

- Advantages
  - Mobility
  - Increased Reliability
  - Ease of Installation
  - Lower cost
  - Rapid Disaster Recovery
- Disadvantages
  - Signal Interference
  - Security
  - Health hazards

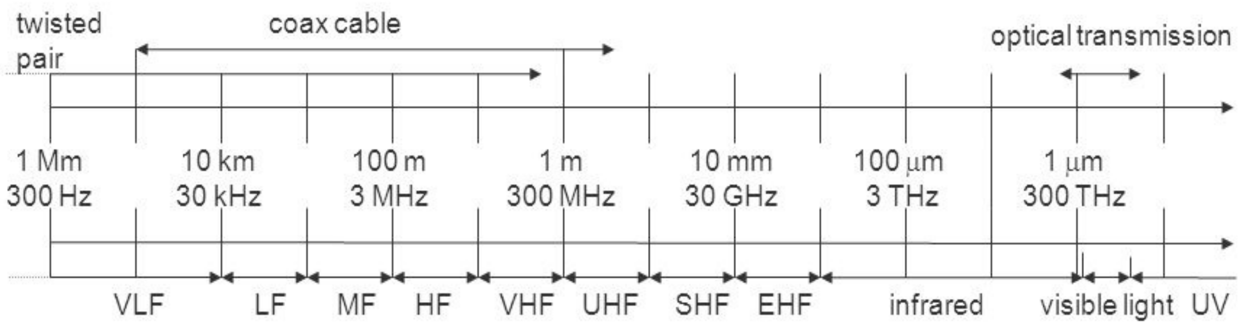
Frequencies for radio transmission

Frequencies for communication

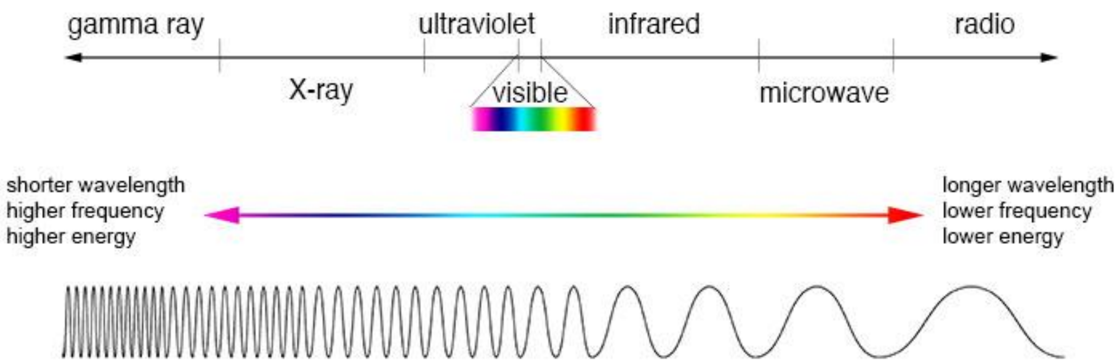
VLF = Very Low Frequency
LF = Low Frequency
MF = Medium Frequency
HF = High Frequency
VHF = Very High Frequency
UHF = Ultra High Frequency
SHF = Super High Frequency
EHF = Extra High Frequency
UV = Ultraviolet Light

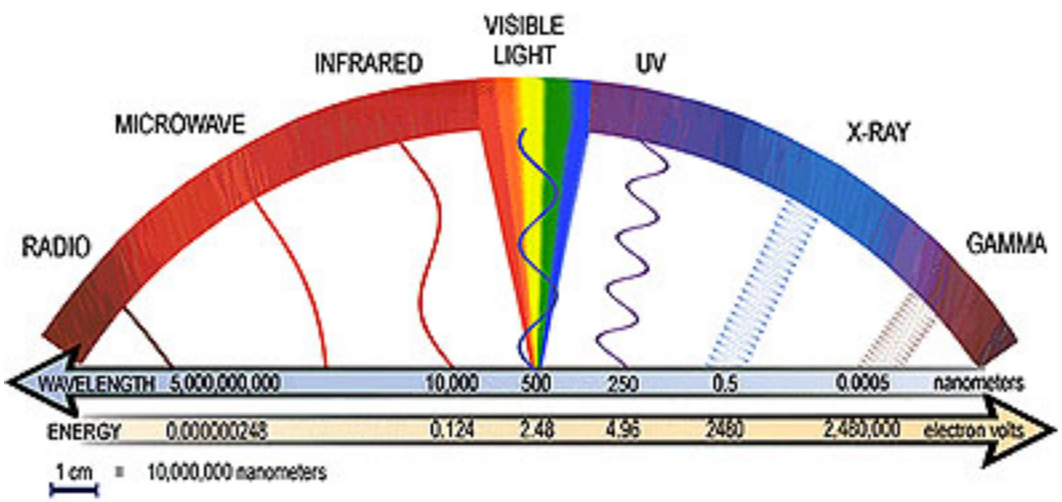
Frequency and wave length

- $\lambda = c/f$
- wave length λ, speed of light $c \cong 3x108m/s$, frequency f



EM SPECTRUM

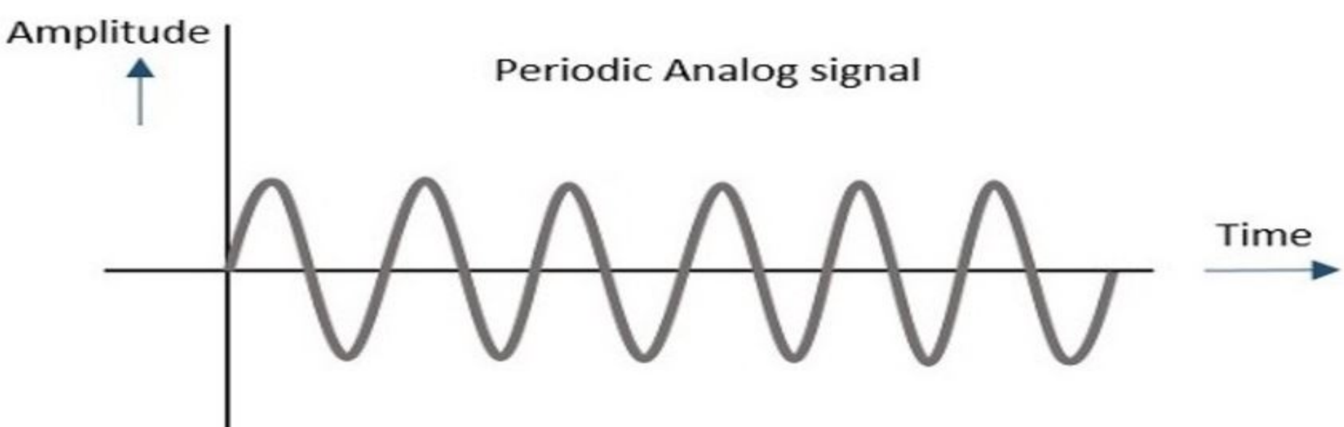

gamma ray
ultraviolet
infrared
radio
X-ray
visible
microwave
shorter wavelength
higher frequency
higher energy
longer wavelength
lower frequency
lower energy


VISIBLE
LIGHT
INFRARED
UV
MICROWAVE
X-RAY
RADIO
GAMMA
WAVELENGTH 5,000,000,000 10,000 500 250 0.5 0.0005 nanometers
ENERGY 0.000000248 0.124 2.48 4.96 2480 2,480,000 electron volts
1 cm = 10,000,000 nanometers

Signals

- Signals are the physical representation of data. Users of a communication system can only exchange data through the transmission of signals.
- Signals for radio transmission are periodic signals, especially sine waves as carriers.

$$s(t) = \underbrace{A_t}_{\text{amplitude}} \sin(2\pi \underbrace{f_t}_{\text{frequency}} t + \underbrace{\varphi_t}_{\text{phase shift}})$$



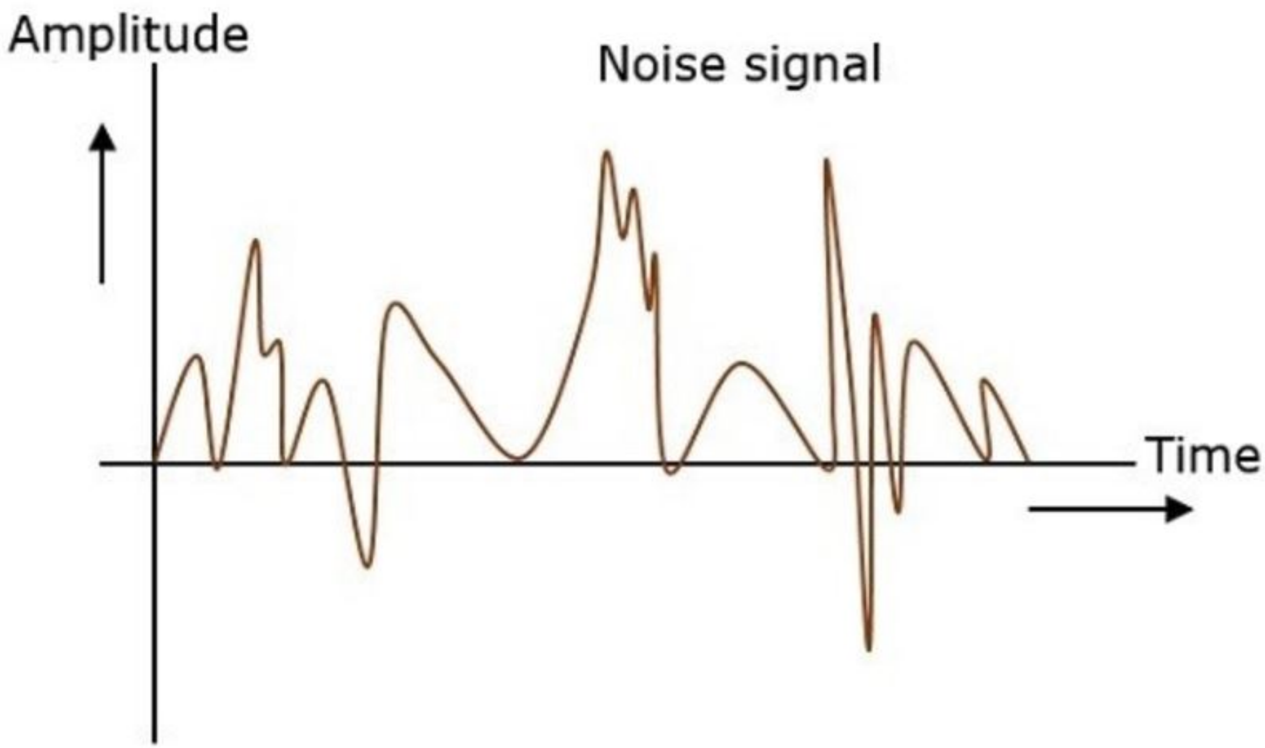
Noise

- In any communication system, during the transmission of the signal or while receiving the signal, some unwanted signal gets introduced into the communication, making it unpleasant for the receiver, and questioning the quality of the communication. Such a disturbance is called as **Noise**.

- Noise is an **unwanted signal**, which interferes with the original message signal and corrupts the parameters of the message signal. This alteration in the communication process, leads to the message getting altered. It most likely enters at the channel or the receiver.

Noise

- The noise signal can be understood by taking a look at the following figure.



Types of Noise

- There are two main ways in which noise is produced. One is through some external source while the other is created by an internal source, within the receiver section.

- **External Source**
  - This noise is produced by the external sources, which may occur in the medium or channel of communication usually. This noise cannot be completely eliminated.
  - Atmospheric noise (due to irregularities in the atmosphere).
  - Extra-terrestrial noise, such as solar noise and cosmic noise.
  - Industrial noise.

Types of Noise

- **Internal Source**
  - This noise is produced by the receiver components while functioning. The components in the circuits, due to continuous functioning, may produce few types of noise. This noise is quantifiable. A proper receiver design may lower the effect of this internal noise.

  - Thermal agitation noise (Johnson noise or Electrical noise)
  - Shot noise (due to the random movement of electrons and holes)
  - Transit-time noise (during transition)
  - Miscellaneous noise is another type of noise which includes flicker, resistance effect and mixer generated noise, etc.

Example & effects of noise

- Most common examples of noise are −
  - Hiss sound in radio receivers
  - Buzz sound amidst of telephone conversations
  - Flicker in television receivers, etc.

- Noise limits the operating range of the systems

- Noise affects the sensitivity of receivers

What is Modulation and Demodulation?

- For a signal to be transmitted to a distance, without the effect of any external interferences or noise addition and without getting faded away, it has to undergo a process called as Modulation.

- It improves the strength of the signal without disturbing the parameters of the original signal.

- A high frequency signal can travel up to a longer distance, without getting affected by external disturbances.

- Demodulation is the process of extracting the baseband message from the carrier so that it may be processed and interpreted by the intended receiver

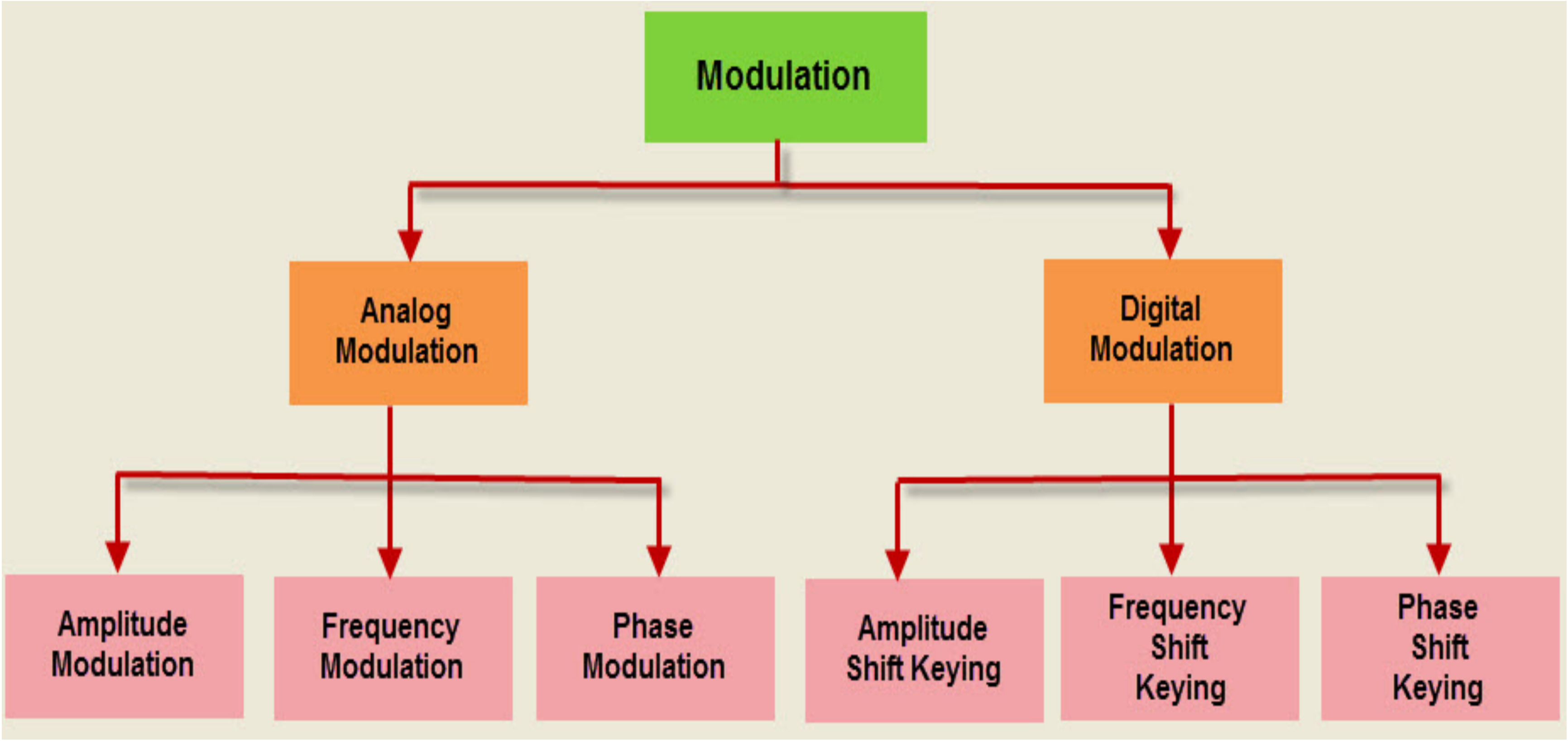
Advantages for Modulation

- Following are some of the advantages for implementing modulation in the communication systems.
  - Reduction of antenna size
  - No signal mixing
  - Increased communication range
  - Multiplexing of signals
  - Possibility of bandwidth adjustments
  - Improved reception quality

Signals in the Modulation Process

- **Message or Modulating Signal**
  - The signal which contains a message to be transmitted, is called as a message signal. It is a baseband signal, which has to undergo the process of modulation, to get transmitted. Hence, it is also called as the modulating signal.
- **Carrier Signal**
  - The high frequency signal, which has a certain amplitude, frequency and phase but contains no information is called as a carrier signal. It is an empty signal and is used to carry the signal to the receiver after modulation.
- **Modulated Signal**
  - The resultant signal after the process of modulation is called as a modulated signal. This signal is a combination of modulating signal and carrier signal.

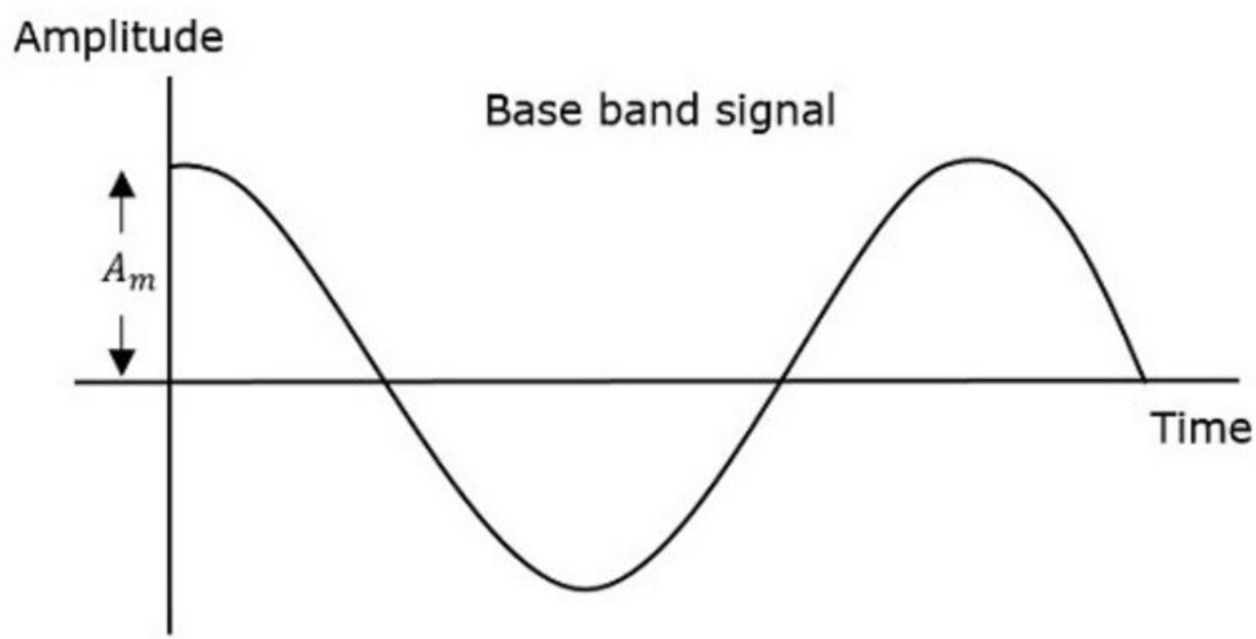
Types of Modulation



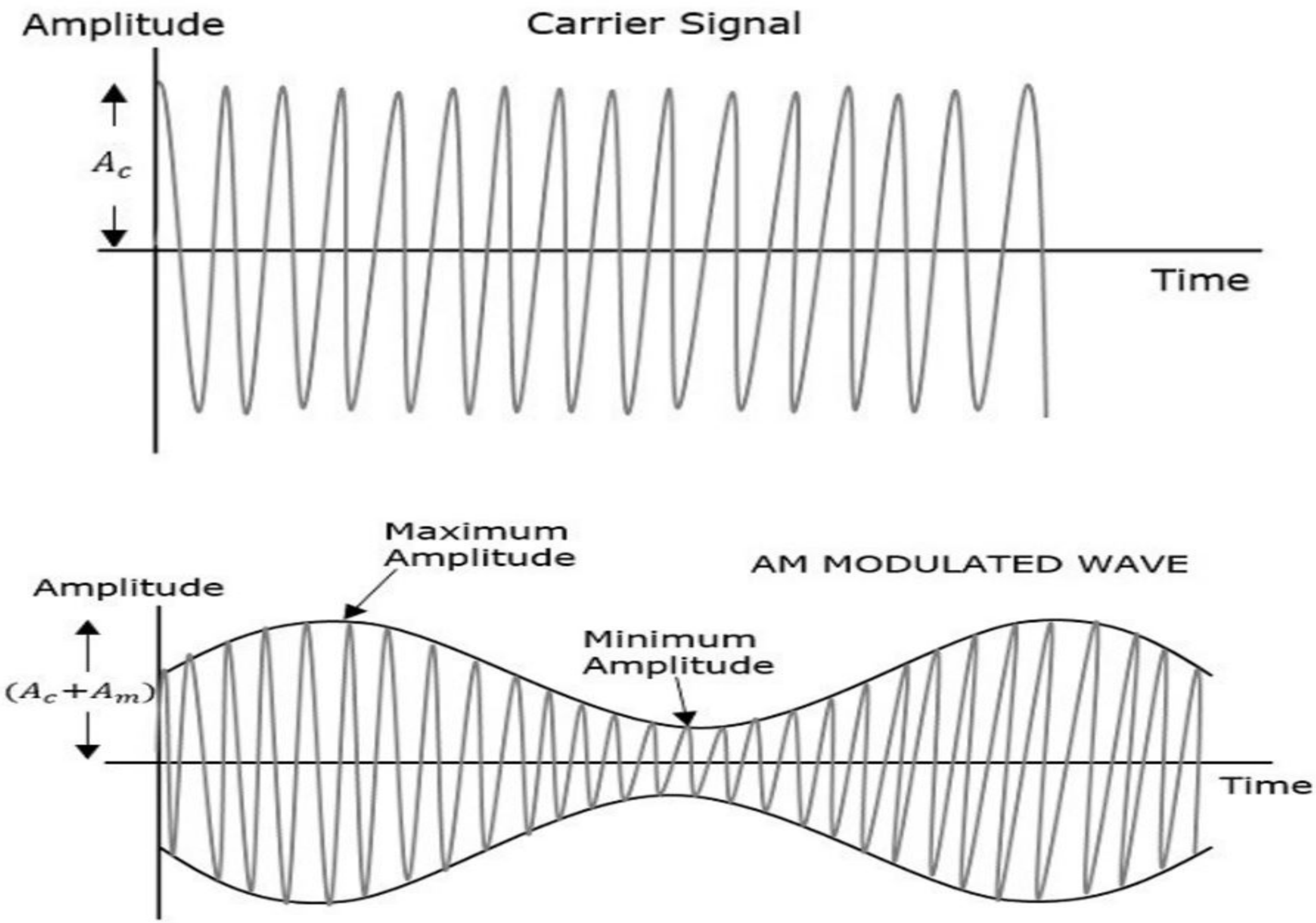
ANALOG MODULATION

Amplitude modulation

- A continuous-waves goes on continuously without any intervals and it is the baseband message signal, which contains the information. This wave has to be modulated.



Amplitude modulation



Mathematical expression

Following are the mathematical expressions for these waves.

Time-domain Representation of the Waves

Let the modulating signal be,

$$m(t) = A_m \cos(2\pi f_m t)$$

and the carrier signal be,

$$c(t) = A_c \cos(2\pi f_c t)$$

Where,

A_m and A_c are the amplitude of the modulating signal and the carrier signal respectively.

f_m and f_c are the frequency of the modulating signal and the carrier signal respectively.

Then, the equation of Amplitude Modulated wave will be

$$s(t) = [A_c + A_m \cos(2\pi f_m t)] \cos(2\pi f_c t) \qquad \text{(Equation 1)}$$

Modulation index

- A carrier wave, after being modulated, if the modulated level is calculated , then such an attempt is called as Modulation Index or Modulation depth.

Rearrange the Equation 1 as below.

$$s(t) = A_c \left[1 + \left(\frac{A_m}{A_c}\right)\cos(2\pi f_m t)\right]\cos(2\pi f_c t)$$

$$\Rightarrow s(t) = A_c\left[1 + \mu\cos(2\pi f_m t)\right]\cos(2\pi f_c t) \qquad \text{(Equation 2)}$$

Where, μ is Modulation index and it is equal to the ratio of A_m and A_c. Mathematically, we can write it as

$$\mu = \frac{A_m}{A_c} \qquad \text{(Equation 3)}$$

Hence, we can calculate the value of modulation index by using the above formula, when the amplitudes of the message and carrier signals are known.

Max and Min Amplitude wave

- Now, let us derive one more formula for Modulation index by considering Equation 1.

- We can use this formula for calculating modulation index value, when the maximum and minimum amplitudes of the modulated wave are known.

- Let Amax and Amin be the maximum and minimum amplitudes of the modulated wave.

Max and Min Amplitude wave

We will get the maximum amplitude of the modulated wave, when $\cos(2\pi f_m t)$ is 1.

$$\Rightarrow A_{\max} = A_c + A_m \qquad \text{(Equation 4)}$$

We will get the minimum amplitude of the modulated wave, when $\cos(2\pi f_m t)$ is -1.

$$\Rightarrow A_{\min} = A_c - A_m \qquad \text{(Equation 5)}$$

Add Equation 4 and Equation 5.

$$A_{\max} + A_{\min} = A_c + A_m + A_c - A_m = 2A_c$$

$$\Rightarrow A_c = \frac{A_{\max} + A_{\min}}{2} \qquad \text{(Equation 6)}$$

Max and Min Amplitude wave

Subtract Equation 5 from Equation 4.

$$A_{\max} - A_{\min} = A_c + A_m - (A_c - A_m) = 2A_m$$

$$\Rightarrow A_m = \frac{A_{\max} - A_{\min}}{2} \qquad \text{(Equation 7)}$$

The ratio of Equation 7 and Equation 6 will be as follows.

$$\frac{A_m}{A_c} = \frac{(A_{max} - A_{min})/2}{(A_{max} + A_{min})/2}$$

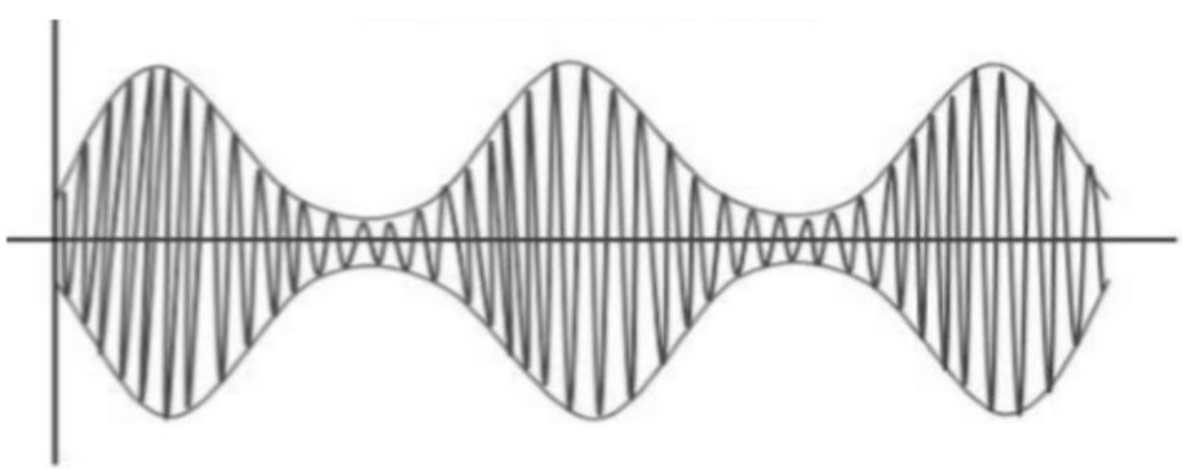
$$\Rightarrow \mu = \frac{A_{\max} - A_{\min}}{A_{\max} + A_{\min}} \qquad \text{(Equation 8)}$$

Therefore, Equation 3 and Equation 8 are the two formulas for Modulation index. The modulation index or modulation depth is often denoted in percentage called as Percentage of Modulation. We will get the **percentage of modulation**, just by multiplying the modulation index value with 100.

For a perfect modulation, the value of modulation index should be 1, which implies the percentage of modulation should be 100%.

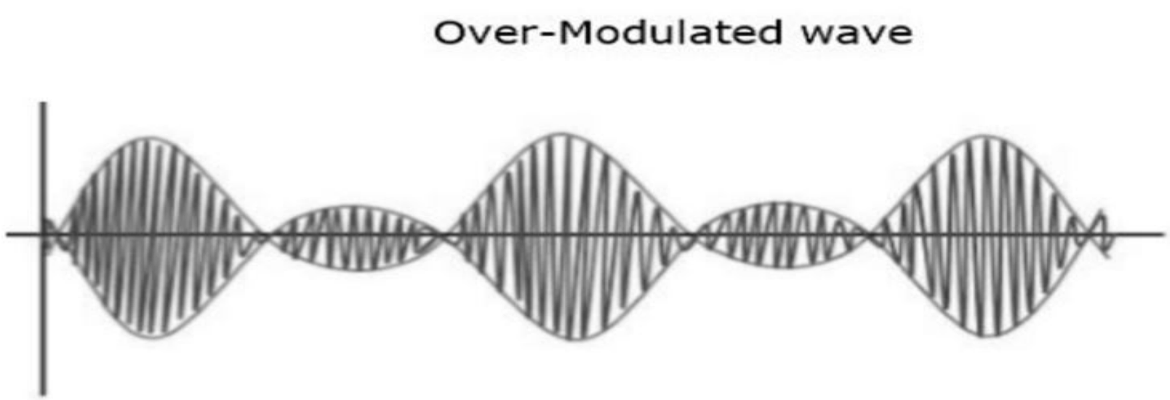
Under modulation

- For instance, if this value is less than 1, i.e., the modulation index is 0.5, then the modulated output would look like the following figure.
- It is called as Under-modulation. Such a wave is called as an under-modulated wave.



Over modulation

- If the value of the modulation index is greater than 1, i.e., 1.5 or so, then the wave will be an over-modulated wave.
- As the value of the modulation index increases, the carrier experiences a 180^{o} phase reversal, which causes additional sidebands and hence, the wave gets distorted.
- Such an over-modulated wave causes interference, which cannot be eliminated.



Bandwidth of AM Wave

- Bandwidth (BW) is the difference between the highest and lowest frequencies of the signal. Mathematically, we can write it as BW=fmax−fmin.

Hence, the amplitude modulated wave has three frequencies. Those are carrier frequency f_c, upper sideband frequency $f_c + f_m$ and lower sideband frequency $f_c - f_m$

Here,

$$f_{max} = f_c + f_m \text{ and } f_{min} = f_c - f_m$$

Substitute, f_{max} and f_{min} values in bandwidth formula.

$$BW = f_c + f_m - (f_c - f_m)$$

$$\Rightarrow BW = 2f_m$$

Thus, it can be said that the bandwidth required for amplitude modulated wave is twice the frequency of the modulating signal.

Power Calculations of AM Wave

Power of AM wave is equal to the sum of powers of carrier, upper sideband, and lower sideband frequency components.

$$P_t = P_c + P_{USB} + P_{LSB}$$

We know that the standard formula for power of cos signal is

$$P = \frac{{v_{rms}}^2}{R} = \frac{\left(v_m/\sqrt{2}\right)^2}{2}$$

Where,

v_{rms} is the rms value of cos signal.

v_m is the peak value of cos signal.

Power Calculations of AM Wave

First, let us find the powers of the carrier, the upper and lower sideband one by one.

Carrier power

$$P_c = \frac{\left(A_c/\sqrt{2}\right)^2}{R} = \frac{{A_c}^2}{2R}$$

Upper sideband power

$$P_{USB} = \frac{\left(A_c\mu/2\sqrt{2}\right)^2}{R} = \frac{{A_c}^2{\mu}^2}{8R}$$

Similarly, we will get the lower sideband power same as that of the upper side band power.

$$P_{LSB} = \frac{{A_c}^2{\mu}^2}{8R}$$

Power Calculations of AM Wave

Now, let us add these three powers in order to get the power of AM wave.

$$P_t = \frac{{A_c}^2}{2R} + \frac{{A_c}^2 \mu^2}{8R} + \frac{{A_c}^2 \mu^2}{8R}$$

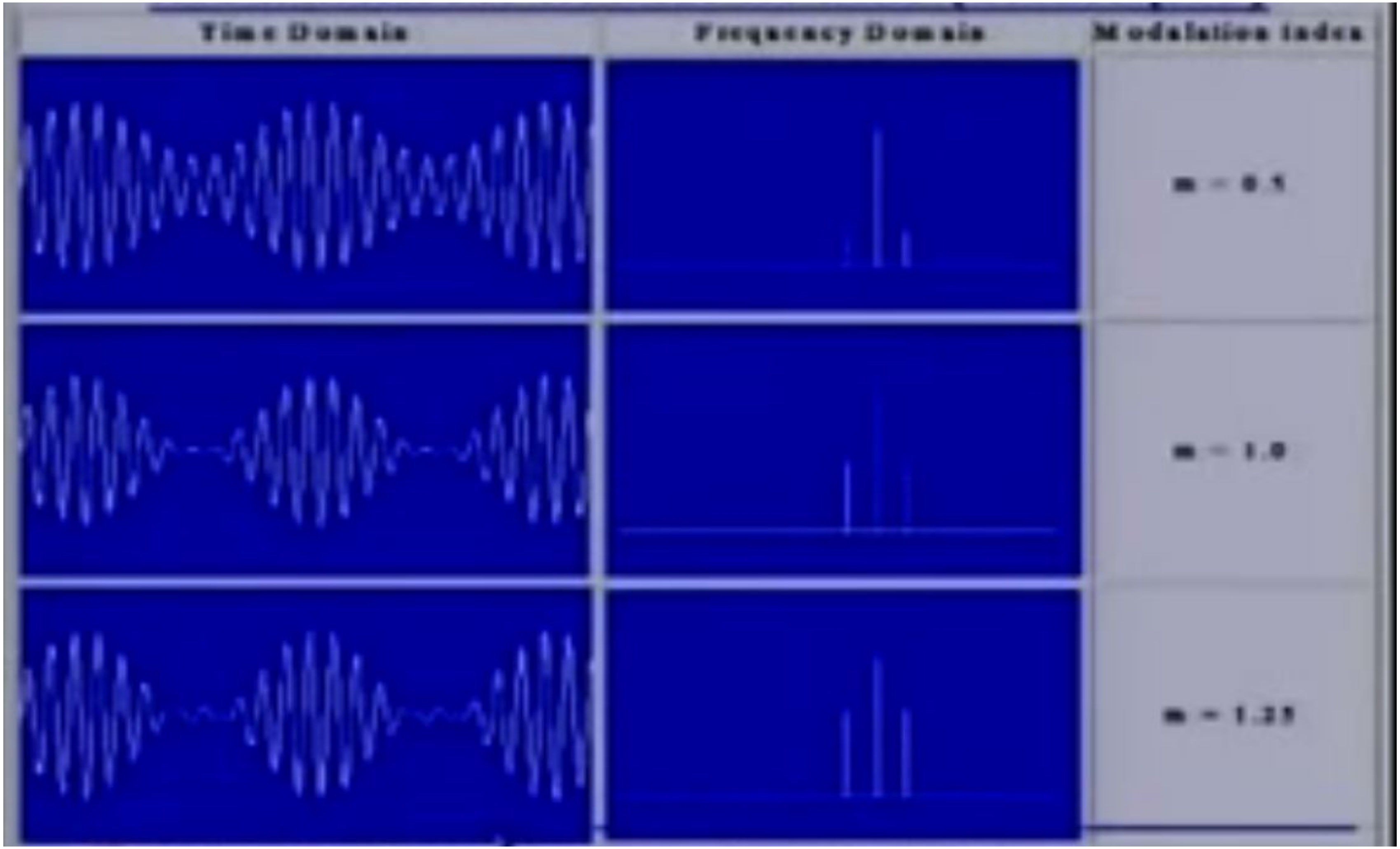
$$\Rightarrow P_t = \left(\frac{{A_c}^2}{2R}\right)\left(1 + \frac{\mu^2}{4} + \frac{\mu^2}{4}\right)$$

$$\Rightarrow P_t = P_c\left(1 + \frac{\mu^2}{2}\right)$$

We can use the above formula to calculate the power of AM wave, when the carrier power and the modulation index are known.

If the modulation index $\mu = 1$ then the power of AM wave is equal to 1.5 times the carrier power. So, the power required for transmitting an AM wave is 1.5 times the carrier power for a perfect modulation.

AM example


Time Domain
Frequency Domain
Modulation index
m = 0.5
m = 1.0
m = 1.25

Problem

A modulating signal $m(t) = 10\cos(2\pi \times 10^3 t)$ is amplitude modulated with a carrier signal $c(t) = 50\cos(2\pi \times 10^5 t)$. Find the modulation index, the carrier power, and the power required for transmitting AM wave.

Solution

Given, the equation of modulating signal as

$$m(t) = 10\cos(2\pi \times 10^3 t)$$

We know the standard equation of modulating signal as

$$m(t) = A_m \cos(2\pi f_m t)$$

By comparing the above two equations, we will get

Amplitude of modulating signal as $A_m = 10 volts$

and Frequency of modulating signal as

$$f_m = 10^3 Hz = 1KHz$$

Problem (con.)

Given, the equation of carrier signal is

$$c(t) = 50\cos\left(2\pi \times 10^5 t\right)$$

The standard equation of carrier signal is

$$c(t) = A_c \cos(2\pi f_c t)$$

By comparing these two equations, we will get

Amplitude of carrier signal as $A_c = 50 volts$

and Frequency of carrier signal as $f_c = 10^5 Hz = 100KHz$

We know the formula for modulation index as

$$\mu = \frac{A_m}{A_c}$$

Substitute, A_m and A_c values in the above formula.

$$\mu = \frac{10}{50} = 0.2$$

Therefore, the value of **modulation index is 0.2** and percentage of modulation is 20%.

Problem (con.)

The formula for Carrier power, $P_c =$ is

$$P_c = \frac{{A_c}^2}{2R}$$

Assume $R = 1\Omega$ and substitute A_c value in the above formula.

$$P_c = \frac{(50)^2}{2\,(1)} = 1250W$$

Therefore, the **Carrier power,** P_c is **1250 watts**.

We know the formula for **power** required for **transmitting AM** wave is

$$\Rightarrow P_t = P_c\left(1 + \frac{\mu^2}{2}\right)$$

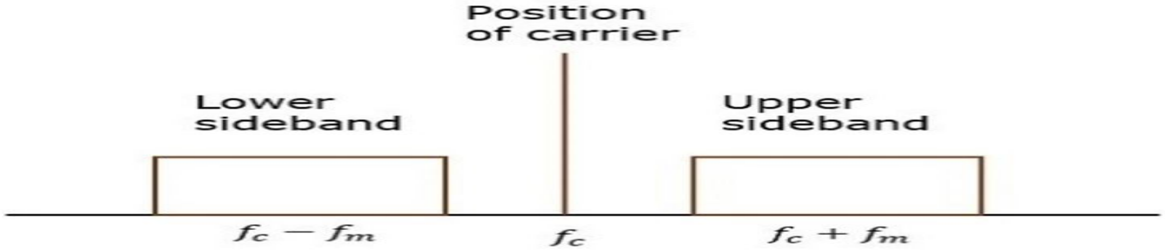
Substitute P_c and μ values in the above formula.

$$P_t = 1250\left(1 + \frac{(0.2)^2}{2}\right) = 1275W$$

Therefore, the **power required for transmitting AM** wave is **1275 watts**.

Double Sideband Full Carrier

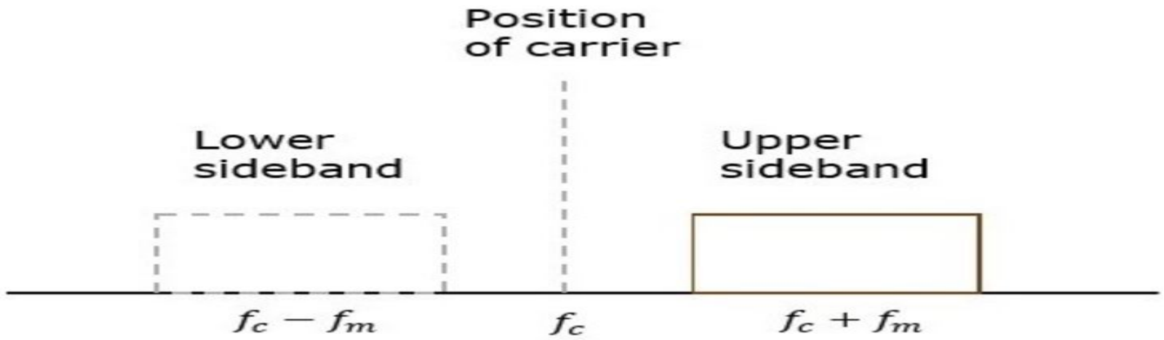
- In the process of Amplitude Modulation, the modulated wave consists of the carrier wave and two sidebands. The modulated wave has the information only in the sidebands.
- Sideband is nothing but a band of frequencies, containing power, which are the lower and higher frequencies of the carrier frequency.
- The transmission of a signal, which contains a carrier along with two sidebands can be termed as Double Sideband Full Carrier system



Single Sideband

- The process of suppressing one of the sidebands along with the carrier and transmitting a single sideband is called as Single Sideband Suppressed Carrier system.

- In the given figure, the carrier and the lower sideband are suppressed. Hence, the upper sideband is used for transmission. Similarly, we can suppress the carrier and the upper sideband while transmitting the lower sideband.



Advantages Disadvantages & Applications

Advantages

- Bandwidth or spectrum space occupied is lesser than AM and DSBSC waves.
- Transmission of more number of signals is allowed.
- Power is saved.
- High power signal can be transmitted.
- Less amount of noise is present.
- Signal fading is less likely to occur.

Disadvantages

- The generation and detection of SSBSC wave is a complex process.
- The quality of the signal gets affected unless the SSB transmitter and receiver have an excellent frequency stability.

Applications

- For power saving requirements and low bandwidth requirements.
- In land, air, and maritime mobile communications.
- In point-to-point communications.
- In radio communications.
- In television, telemetry, and radar communications.
- In military communications, such as amateur radio, etc.

Angle Modulation

- Angle of the carrier is varied according to the amplitude of modulating signal.

Two types of angle modulation

- **Frequency Modulation**
  - Instantaneous frequency is varied according to modulating signal. FM is also called constant envelop.
- **Phase Modulation**
  - Instantaneous phase of the carrier is varied according to modulating signal.

Angle Modulation

The standard equation of the angle modulated wave is

$$s(t) = A_c \cos\theta_i(t)$$

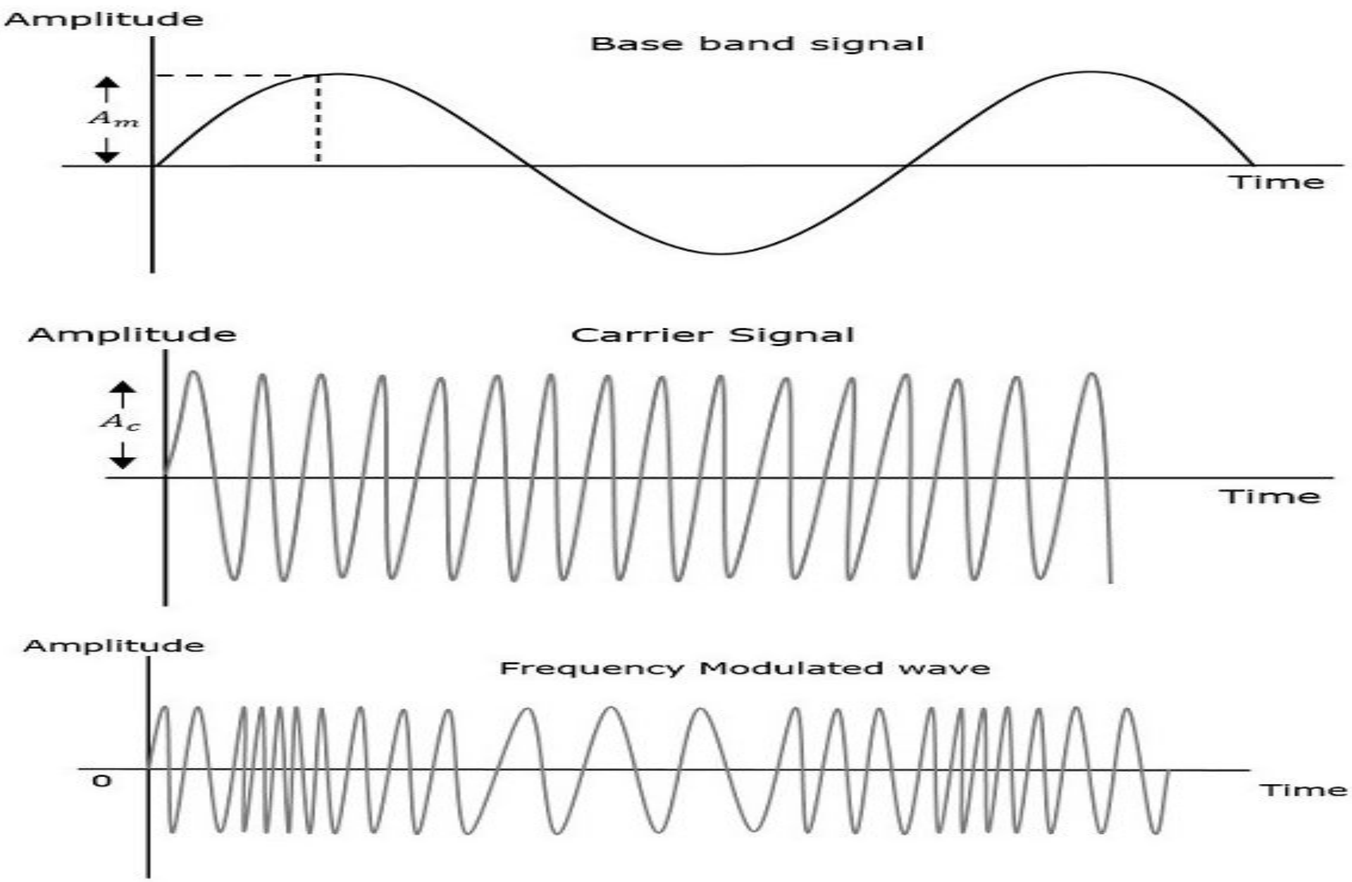
Where,

A_c is the amplitude of the modulated wave, which is the same as the amplitude of the carrier signal

$\theta_i(t)$ is the angle of the modulated wave

Frequency Modulation

- In Frequency Modulation (FM), the frequency of the carrier signal varies in accordance with the instantaneous amplitude of the modulating signal.



Frequency Modulation

- The frequency of the modulated wave increases, when the amplitude of the modulating or message signal increases.

- Similarly, the frequency of the modulated wave decreases, when the amplitude of the modulating signal decreases.

- Note that, the frequency of the modulated wave remains constant and it is equal to the frequency of the carrier signal, when the amplitude of the modulating signal is zero.

Mathematical expression

The equation for instantaneous frequency f_i in FM modulation is

$$f_i = f_c + k_f m(t)$$

Where,

f_c is the carrier frequency

k_t is the frequency sensitivity

$m(t)$ is the message signal

We know the relationship between angular frequency ω_i and angle $\theta_i(t)$ as

$$\omega_i = \frac{d\theta_i(t)}{dt}$$

$$\Rightarrow 2\pi f_i = \frac{d\theta_i(t)}{dt}$$

$$\Rightarrow \theta_i(t) = 2\pi \int f_i dt$$

Substitute, f_i value in the above equation.

$$\theta_i(t) = 2\pi \int (f_c + k_f m(t))\, dt$$

$$\Rightarrow \theta_i(t) = 2\pi f_c t + 2\pi k_f \int m(t)\, dt$$

Substitute, $\theta_i(t)$ value in the standard equation of angle modulated wave.

$$s(t) = A_c \cos\left(2\pi f_c t + 2\pi k_f \int m(t)\, dt\right)$$

This is the **equation of FM wave**.

Modulation Index FM

If the modulating signal is $m(t) = A_m \cos(2\pi f_m t)$, then the equation of FM wave will be

$$s(t) = A_c \cos(2\pi f_c t + \beta \sin(2\pi f_m t))$$

Where,

$$\beta = \textbf{\textit{modulation index}} = \frac{\Delta f}{f_m} = \frac{k_f A_m}{f_m}$$

The difference between FM modulated frequency (instantaneous frequency) and normal carrier frequency is termed as **Frequency Deviation**. It is denoted by Δf, which is equal to the product of k_f and A_m.

Narrow and Wide band FM

- FM can be divided into Narrowband FM and Wideband FM based on the values of modulation index β.

Narrowband FM

Following are the features of Narrowband FM.

- This frequency modulation has a small bandwidth when compared to wideband FM.
- The modulation index β is small, i.e., less than 1.
- Its spectrum consists of the carrier, the upper sideband and the lower sideband.
- This is used in mobile communications such as police wireless, ambulances, taxicabs, etc.

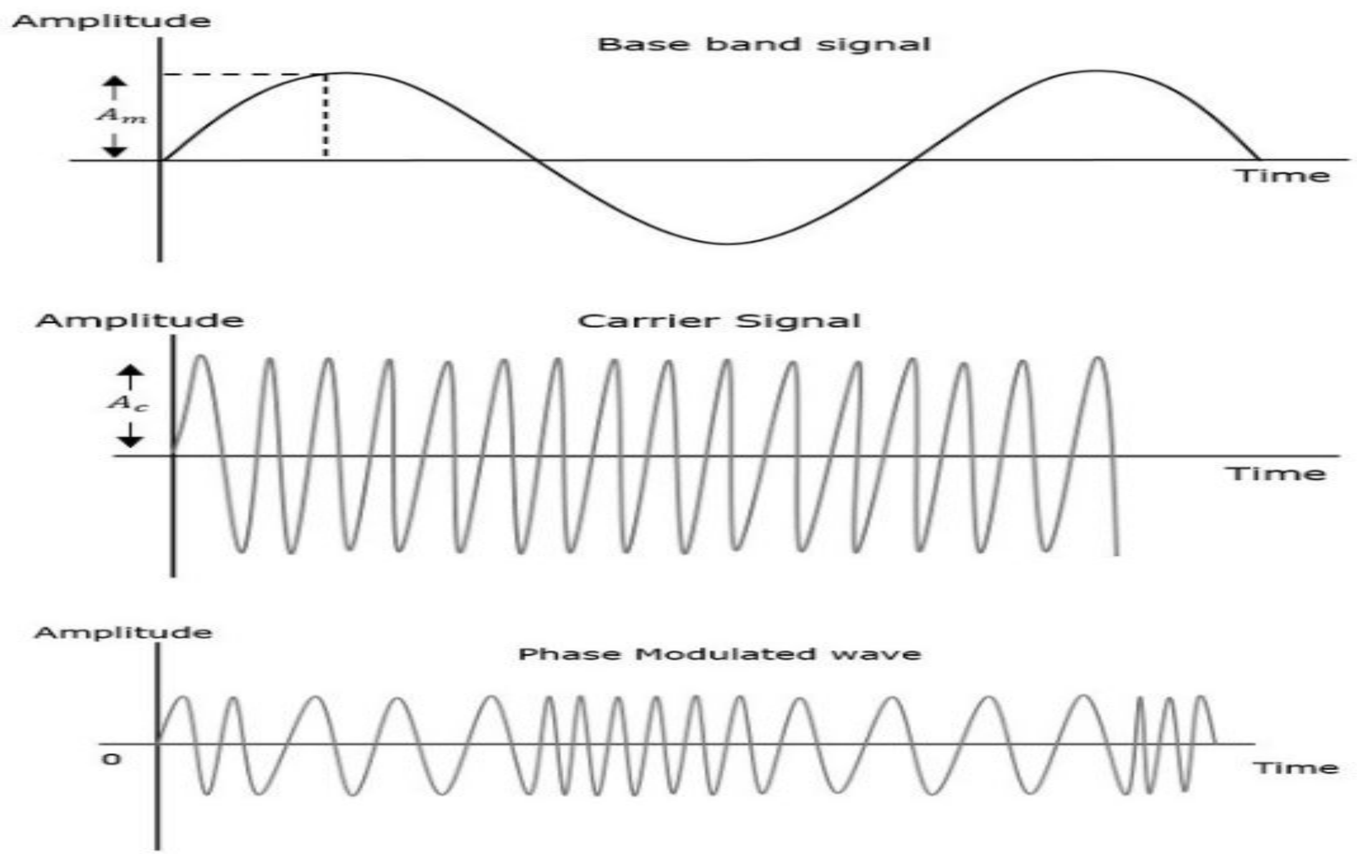
Wideband FM

Following are the features of Wideband FM.

- This frequency modulation has infinite bandwidth.
- The modulation index β is large, i.e., higher than 1.
- Its spectrum consists of a carrier and infinite number of sidebands, which are located around it.
- This is used in entertainment, broadcasting applications such as FM radio, TV, etc.

Phase Modulation

- In Phase Modulation (PM), the phase of the carrier signal varies in accordance with the instantaneous amplitude of the modulating signal.



Phase Modulation

- The phase of the modulated wave has got infinite points, where the phase shift in a wave can take place.
- The instantaneous amplitude of the modulating signal changes the phase of the carrier signal.
- When the amplitude is positive, the phase changes in one direction and if the amplitude is negative, the phase changes in the opposite direction.

Mathematical expression

The equation for instantaneous phase ϕ_i in phase modulation is

$$\phi_i = k_p m(t)$$

Where,

- k_p is the phase sensitivity
- $m(t)$ is the message signal

The standard equation of angle modulated wave is

$$s(t) = A_c \cos(2\pi f_c t + \phi_i)$$

Substitute, ϕ_i value in the above equation.

$$s(t) = A_c \cos(2\pi f_c t + k_p m(t))$$

This is the **equation of PM wave**.

Modulation Index PM

If the modulating signal, $m(t) = A_m \cos(2\pi f_m t)$, then the equation of PM wave will be

$$s(t) = A_c \cos(2\pi f_c t + \beta \cos(2\pi f_m t))$$

Where,

- β = ***modulation index*** = $\Delta\phi = k_p A_m$
- $\Delta\phi$ is phase deviation

Phase modulation is used in mobile communication systems, while frequency modulation is used mainly for FM broadcasting.

Problem

A sinusoidal modulating waveform of amplitude 5 V and a frequency of 2 KHz is applied to FM generator, which has a frequency sensitivity of 40 Hz/volt. Calculate the frequency deviation, modulation index, and bandwidth.

Solution

Given, the amplitude of modulating signal, $A_m = 5V$

Frequency of modulating signal, $f_m = 2KHz$

Frequency sensitivity, $k_f = 40Hz/volt$

We know the formula for Frequency deviation as

$$\Delta f = k_f A_m$$

Substitute k_f and A_m values in the above formula.

$$\Delta f = 40 \times 5 = 200Hz$$

Therefore, **frequency deviation**, Δf is $200Hz$

Problem (con.)

The formula for modulation index is

$$\beta = \frac{\Delta f}{f_m}$$

Substitute Δf and f_m values in the above formula.

$$\beta = \frac{200}{2 \times 1000} = 0.1$$

Here, the value of **modulation index**, β is 0.1, which is less than one. Hence, it is Narrow Band FM.

The formula for Bandwidth of Narrow Band FM is the same as that of AM wave.

$$BW = 2f_m$$

Substitute f_m value in the above formula.

$$BW = 2 \times 2K = 4KHz$$

Therefore, the **bandwidth** of Narrow Band FM wave is $4KHz$.

MULTIPLEXING AND MULTIPLE ACCESS

Contents

- Multiple Access
- Multiplexing
  - – FDM
  - – TDM
  - – CDM

Multiple Access

- In today's data communications systems there is a need for several users to share a common channel resource at the same time.

- The resource could be:
  - • high speed optical fibre links between continents
  - • frequency spectrum in a cellular telephone system
  - • twisted pair 'ethernet' cable in the office

Multiple Access

- For multiple users to be able to share a common resource in a managed and effective way, it requires:

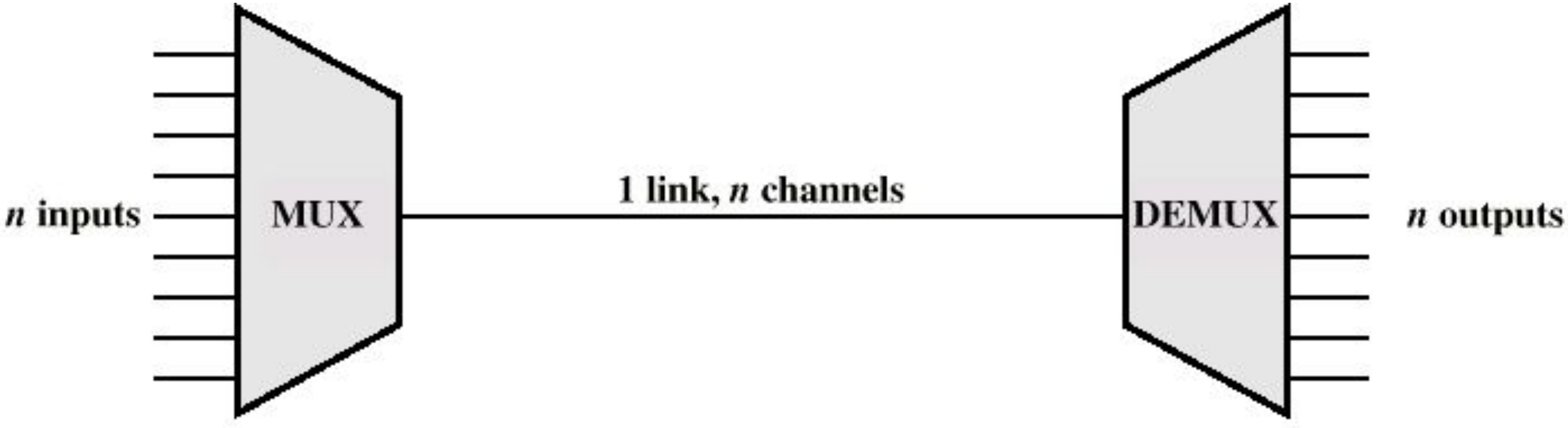
- Some form of access protocol
  - • Defines how or when the sharing is to take place and the means for identifying individual messages. Process is known as multiplexing in wired networks and multiple access in wireless digital communications.

Multiplexing/Multiple Access

- There 3 possible ways to divide the frequency spectrum among many channels:

- Frequency-division multiplexing (FDM) / Frequency Division Multiple Access (FDMA)
- Time-division multiplexing (TDM) / Time Division Multiple Access (TDMA)
- Code-division multiplexing (CDM) / Code Division Multiple Access (CDMA)

Multiplexing

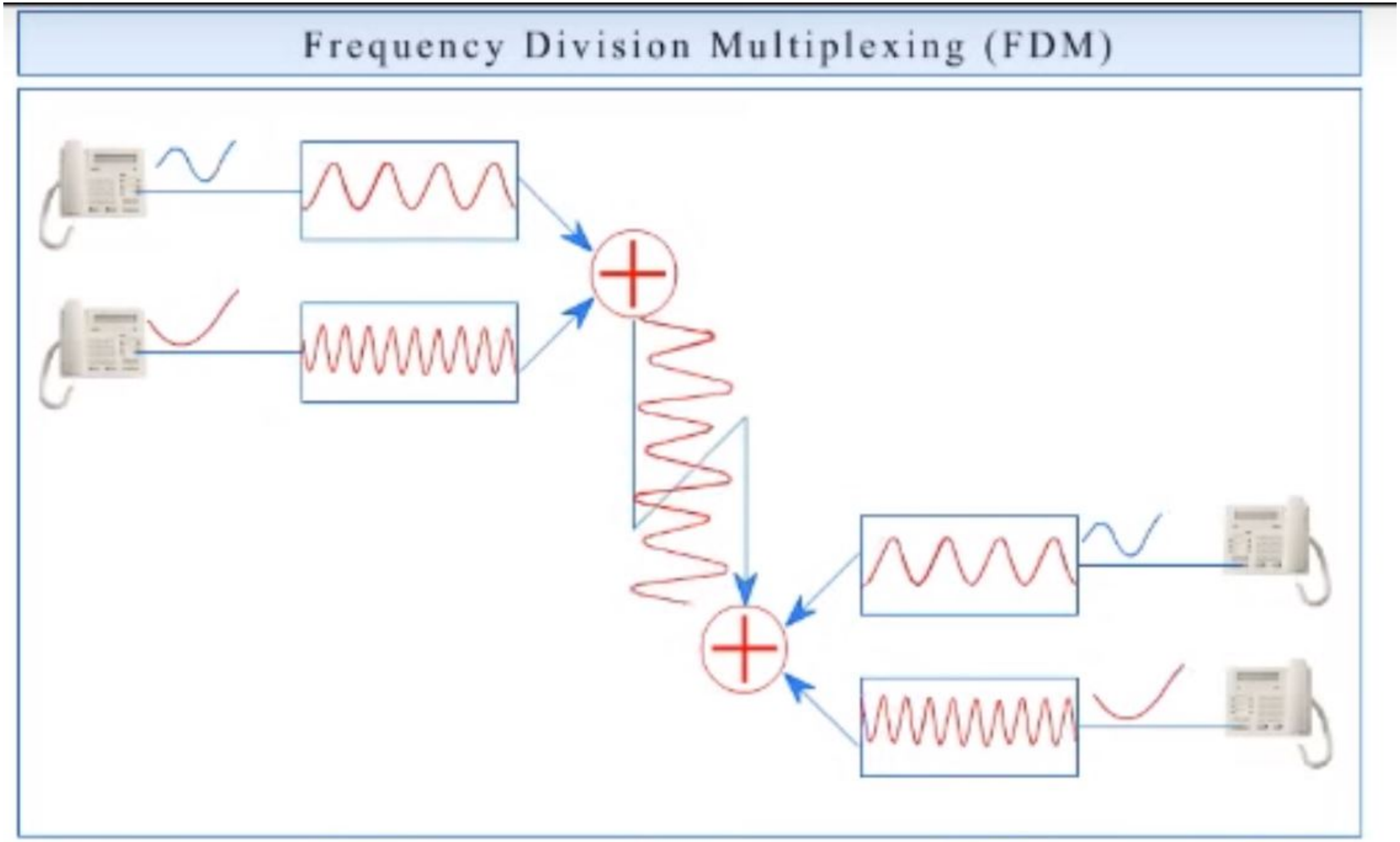


Frequency Division Multiplexing

- In analog multiplexing, the most used technique is Frequency Division Multiplexing (FDM). This technique uses various frequencies to combine streams of data, for sending them on a communication medium, as a single signal.

- Example – A traditional television transmitter, which sends a number of channels through a single cable uses FDM.

Frequency Division Multiplexing



Frequency Division Multiplexing

- Channels can be separated by strips of unused bandwidth- Guard bands.

- Guard bands- to prevent from overlapping

Time-division multiplexing

- In TDM, the time frame is divided into slots. This technique is used to transmit a signal over a single communication channel, by allotting one slot for each message.

- Of all the types of TDM, the main ones are Synchronous and Asynchronous TDM.
  - Synchronous TDM
  - Asynchronous TDM

Synchronous TDM

- In Synchronous TDM, the input is connected to a frame. If there are ‘n’ number of connections, then the frame is divided into ‘n’ time slots. One slot is allocated for each input line.

- In this technique, the sampling rate is common for all signals and hence the same clock input is given. The MUX allocates the same slot to each device at all times.

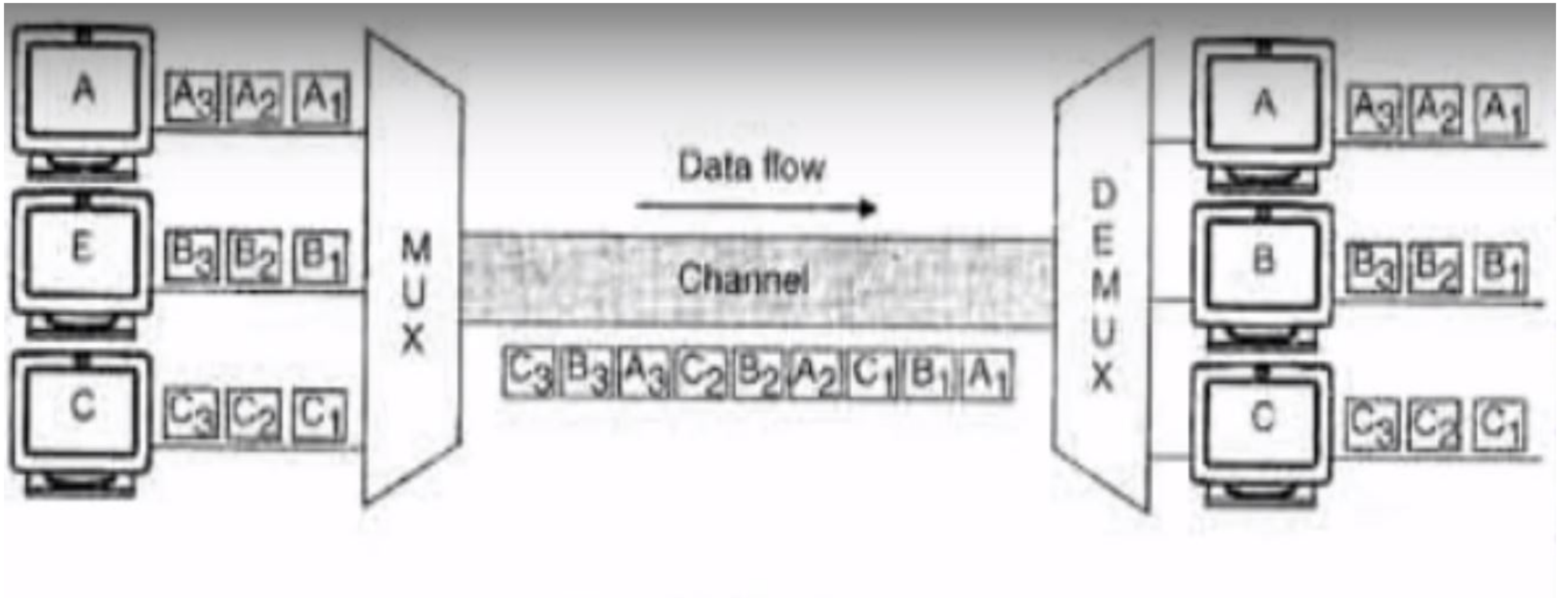
Asynchronous TDM

- In Asynchronous TDM, the sampling rate is different for each of the signals and a common clock is not required. If the allotted device, for a time slot transmits nothing and sits idle, then that slot is allotted to another device, unlike synchronous.

- This type of TDM is used in Asynchronous transfer mode networks.

TDM

- Multiple transmissions can occupy a single link by subdividing them and interleaving the portion.
- The link is shown sectioned by time rather than frequency.



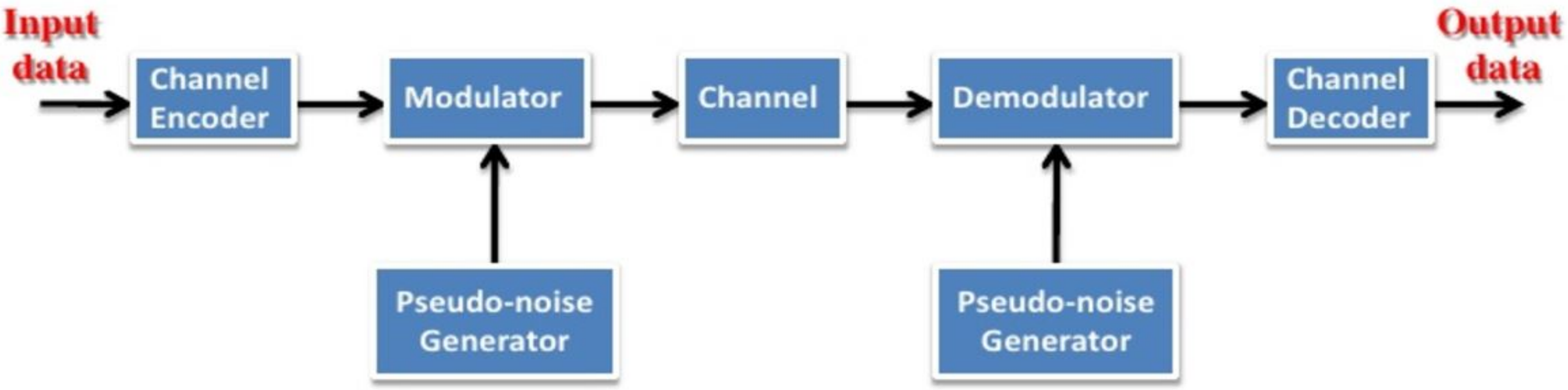
Time Division Multiplexing (TDM)

Code division multiplexing

- CDM is a fixed assignment access technique that uses spread spectrum and special kind of coding scheme to allow the transmitter to share the media at the same time.
- It allows multiple groups to share the same channel at the same time by assigning each group to different code.

Code division multiplexing

- Modulation step
  - Generate a local pseudo-random code with the higher rate than the data to be transmitted.
  - XOR the data which need to be transmitted with the generated code.



General Model of Spread Spectrum Digital Communication System