# UNIT-5

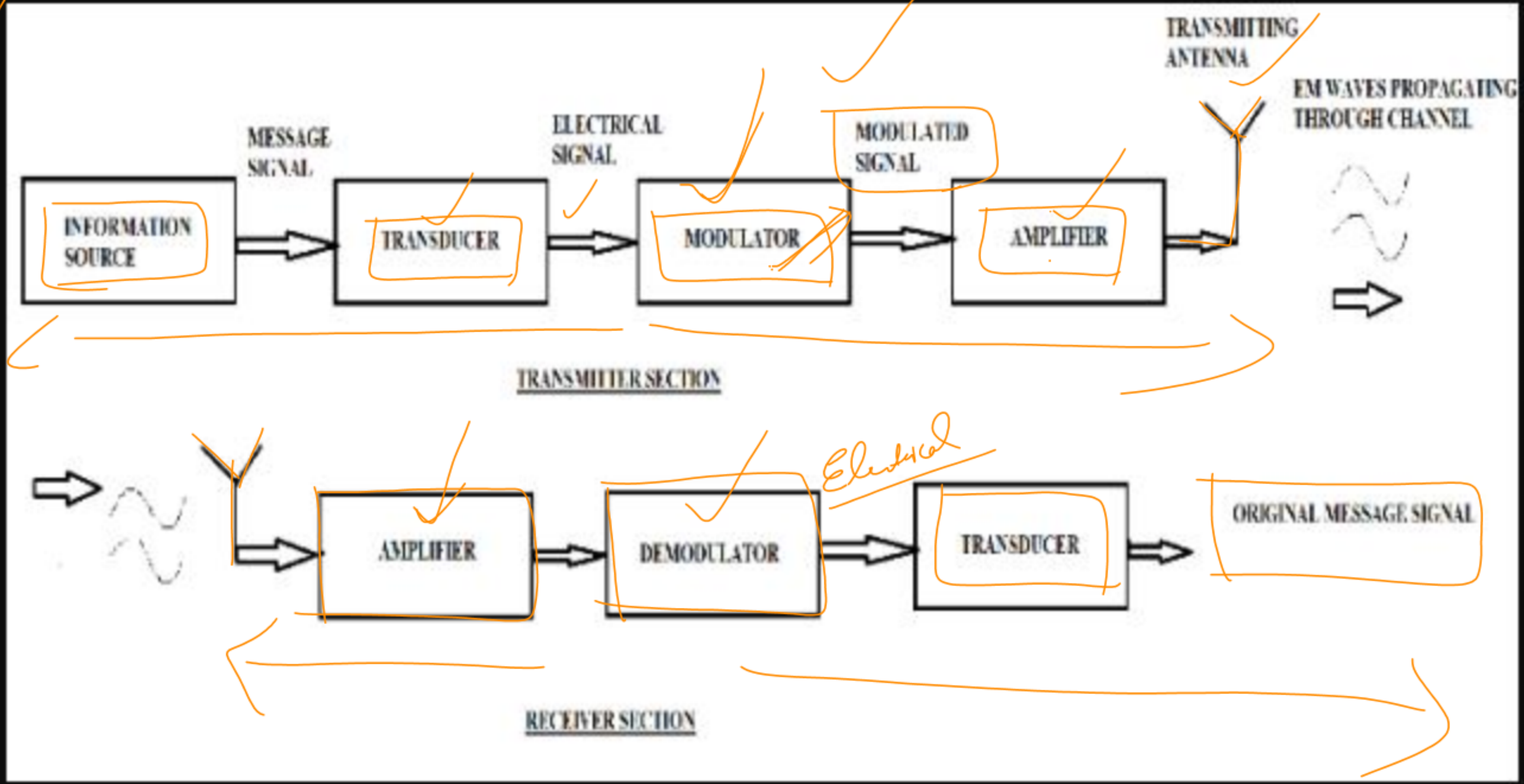
# ONE SHOT REVISION

As per

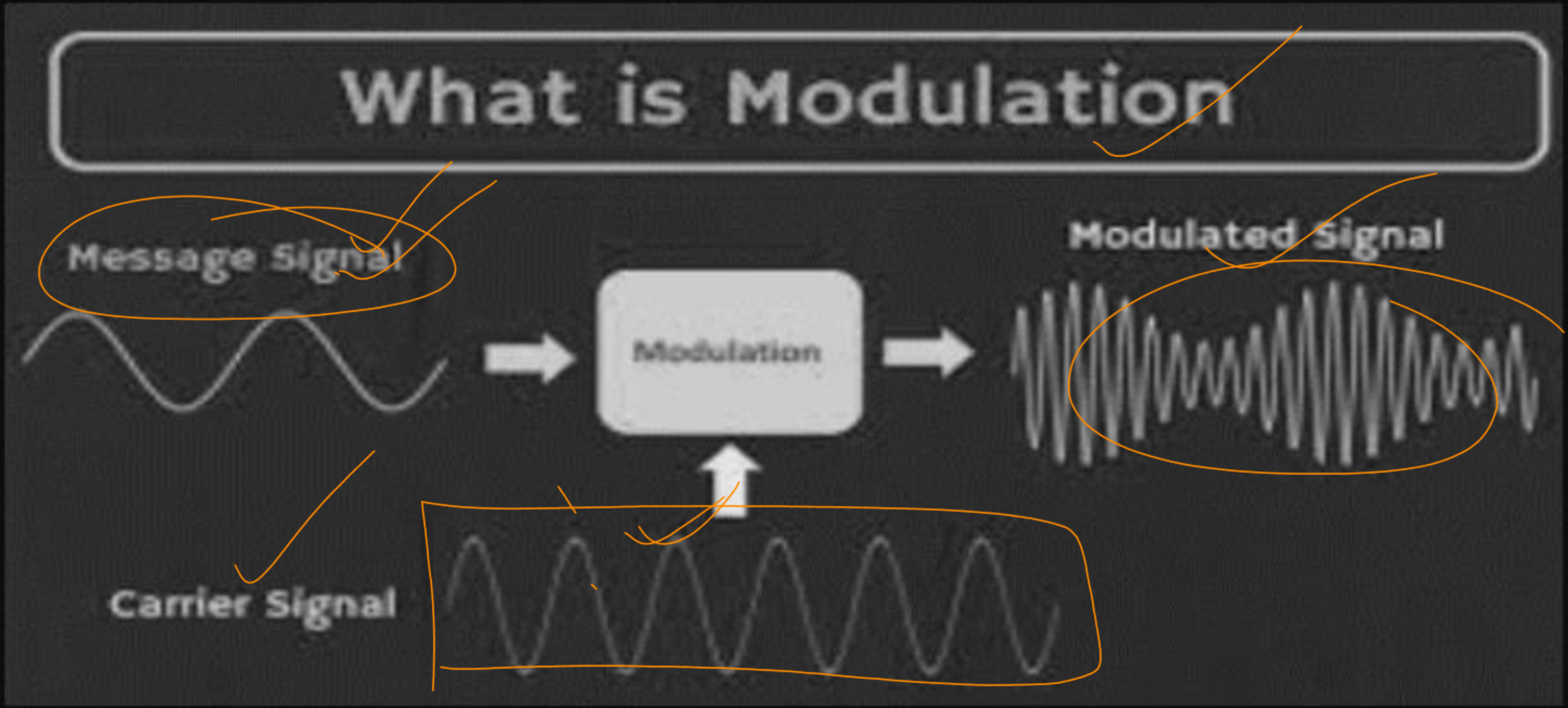
New Syllabus

2022-23

# Block Diagram of Communication System



# Modulation


What is Modulation
Message Signal
Modulation
Modulated Signal
Carrier Signal

## Need of Modulation

There are several factors due to which modulation is needed in communication:-

**Interference or Mixing Problem:** As message signals are generally low frequency signals there is large probability of mixing with other signals of the same frequency range already present in the atmosphere. So, low frequency message signals are sent through high frequency carrier wave (modulation) to avoid such problems.

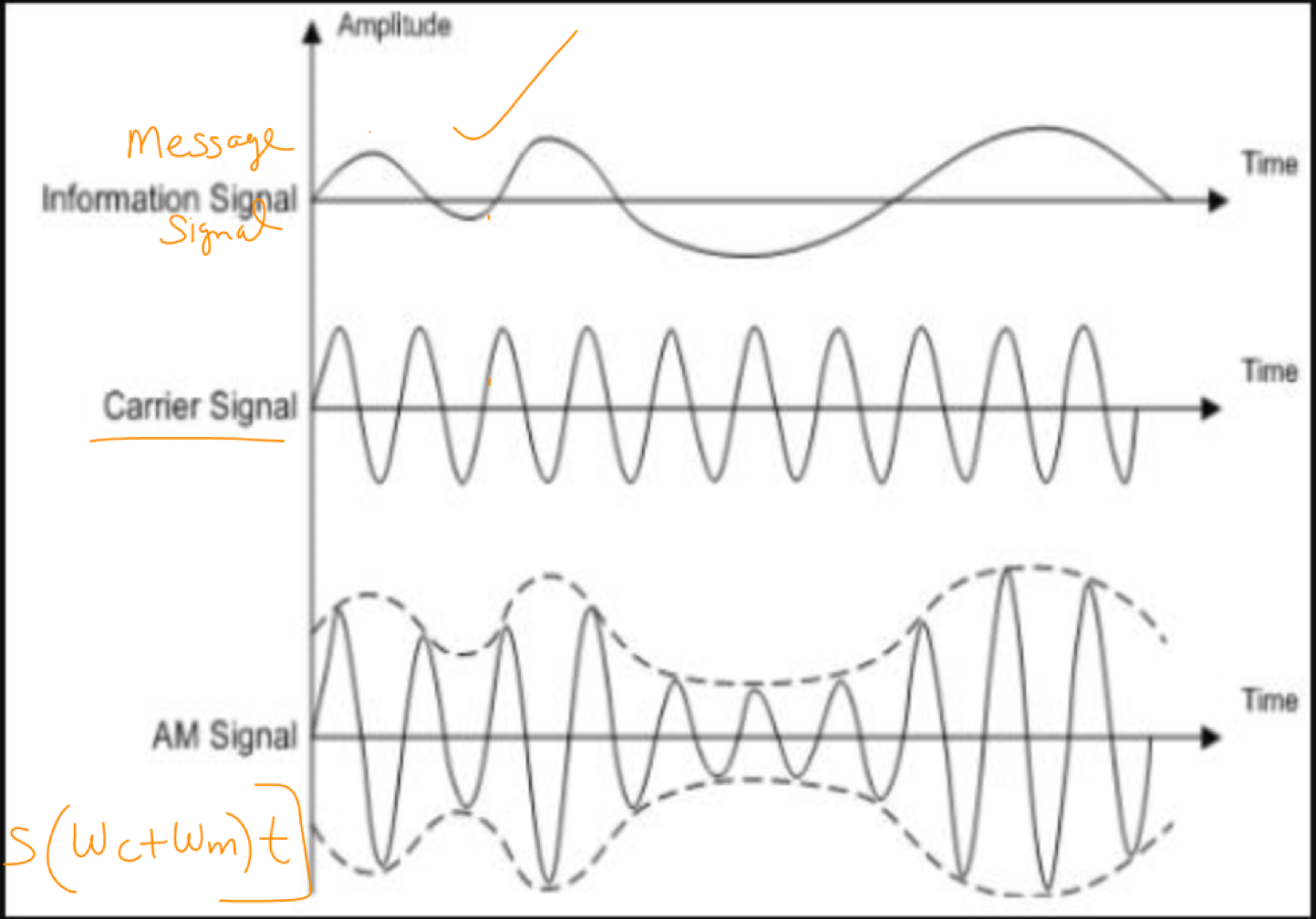
$h \propto \frac{\lambda}{4}$ $c = \lambda f$ $f \propto \frac{1}{\lambda}$

**Height of Antenna:** Practical height of transmitting or receiving antenna = λ/4, where λ is the wavelength of the signal being used. If we use low frequency message signal without modulation the height of antenna is of the order of kilometers. Therefore to reduce the height of antenna modulation is needed.

**Power Dissipation:** When an electromagnetic wave is travelling. A through atmosphere it suffers from various losses which are inversely proportional to the frequency of the signal. Thus low frequency signals are more prone to atmospheric losses and therefore modulation is used to reduce these losses.

# Amplitude Modulation (AM)

In amplitude modulation the amplitude of the carrier signal is modulated according to the instantaneous amplitude of the message signal.




$m(t) = A_m \sin w_m t$

$c(t) = A_c \sin w_c t$

$m(t) = (A_c + m(t)) \sin w_c t$

$= A_c \sin w_c t + \frac{2 A_m \sin w_m t \sin w_c t}{2}$

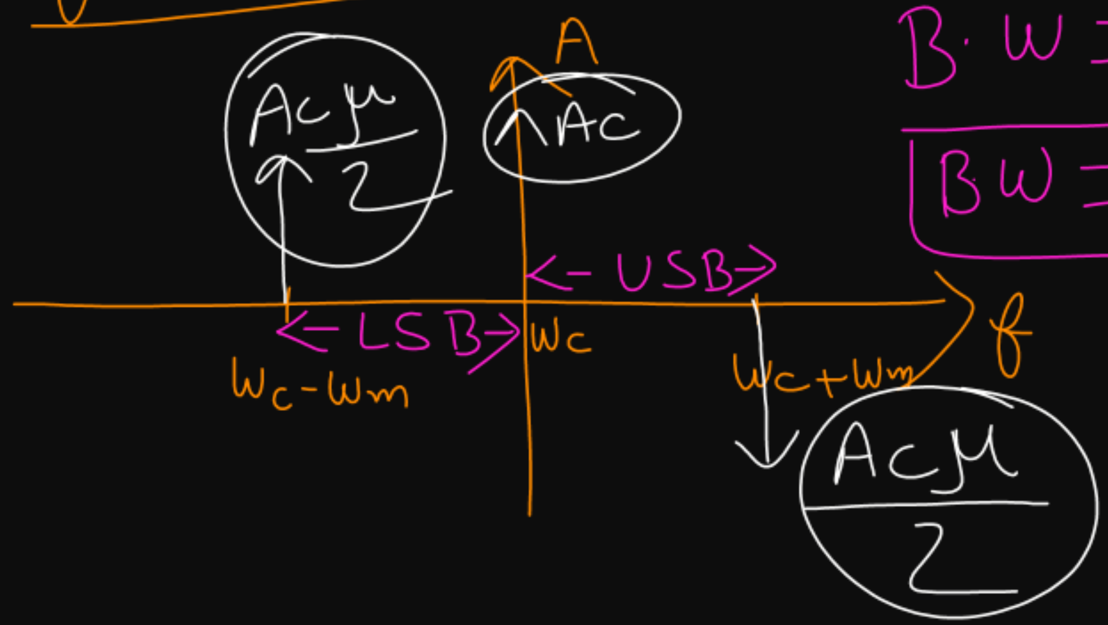
$= A_c \sin w_c t + \frac{A_m}{2} [\cos(w_c - w_m)t - \cos(w_c + w_m)t]$

$= A_c [\sin w_c t + \frac{A_m}{2 A_c} [\cos(w_c - w_m)t - \cos(w_c + w_m)t]]$

$\frac{A_m}{A_c} = \text{modulation Index}(\mu)$

$= (A_c \sin w_c t + \frac{A_c \mu}{2} \cos(w_c - w_m)t - \frac{A_c \mu}{2} \cos(w_c + w_m)t)$

# Frequency spectrum




$$B \cdot W = (W_c + W_m) - (W_c - W_m)$$

$$\boxed{BW = 2\,W_m}$$

$$\boxed{B \cdot W = 2 f_m}$$

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

$$= \frac{\left(\frac{A_c}{\sqrt{2}}\right)^2}{R} + \frac{\left(\frac{A_c\mu}{2\sqrt{2}}\right)^2}{R} + \frac{\left(\frac{A_c\mu}{2\sqrt{2}}\right)^2}{R}$$

$$= \underbrace{\frac{\left(\frac{A_c}{\sqrt{2}}\right)^2}{R}}_{P_c}\left[1 + \frac{\mu^2}{4} + \frac{\mu^2}{4}\right] \Rightarrow \boxed{P_{Total} = P_c\left[1 + \frac{\mu^2}{2}\right]}$$

$$\eta = \frac{\text{Useful Power}}{\text{Total Power}}$$

$$= \frac{P_{USB} + P_{LSB}}{P_{Total}}$$

$$= \frac{\cancel{P_c}\frac{\mu^2}{4} + \cancel{P_c}\frac{\mu^2}{4}}{\cancel{P_c}\left[1 + \frac{\mu^2}{2}\right]}$$

$$= \frac{\mu^2/2}{1 + \frac{\mu^2}{2}} = \frac{1/2}{1 + 1/2}$$

$$= \frac{1}{3} \times 100\ \%$$

$$\boxed{\eta = 33.33\ \%}$$

$$2\pi f = \omega$$

$$P = \frac{V^2}{R}$$

$$\boxed{P = \frac{V_{rms}^2}{R}}$$

$$y = A \sin \omega t$$

$$\frac{A}{\sqrt{2}}$$

$$1 = \mu = \frac{A_m}{A_c}$$

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

$\mu$ $P_c$ $P_{Total}$

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

$c(t) = 50\cos(2\pi \times 10^5 t)$ $A_c = 50$ $f_c = 10^5$

$$\boxed{\text{Modulation Index}(\mu) = \frac{A_m}{A_c} = \frac{10}{50} = 0.2}$$

$$P_c = \frac{(A_c/\sqrt{2})^2}{R = 1\Omega} = \left(\frac{50}{\sqrt{2}}\right)^2 = \frac{2500}{2} = 1250 \text{ Watt}$$

$$P_{Total} = P_c\left[1 + \frac{\mu^2}{2}\right] = 1250\left[1 + \frac{(0.2)^2}{2}\right] = 1275 \text{ Watt}$$

$$P_{USB} = P_{LSB} = \frac{P_c \mu^2}{4} = 1250\frac{(0.2)^2}{4} = 12.5 \text{ watt}$$

$$P_{SB} = P_{USB} + P_{LSB} = 25 \text{ watt}$$

$$B.W = 2f_m = 2000 \text{ Htz}$$

$$f_{USB} = f_c + f_m = 10^5 + 10^3 = 101000 \text{ Htz}$$

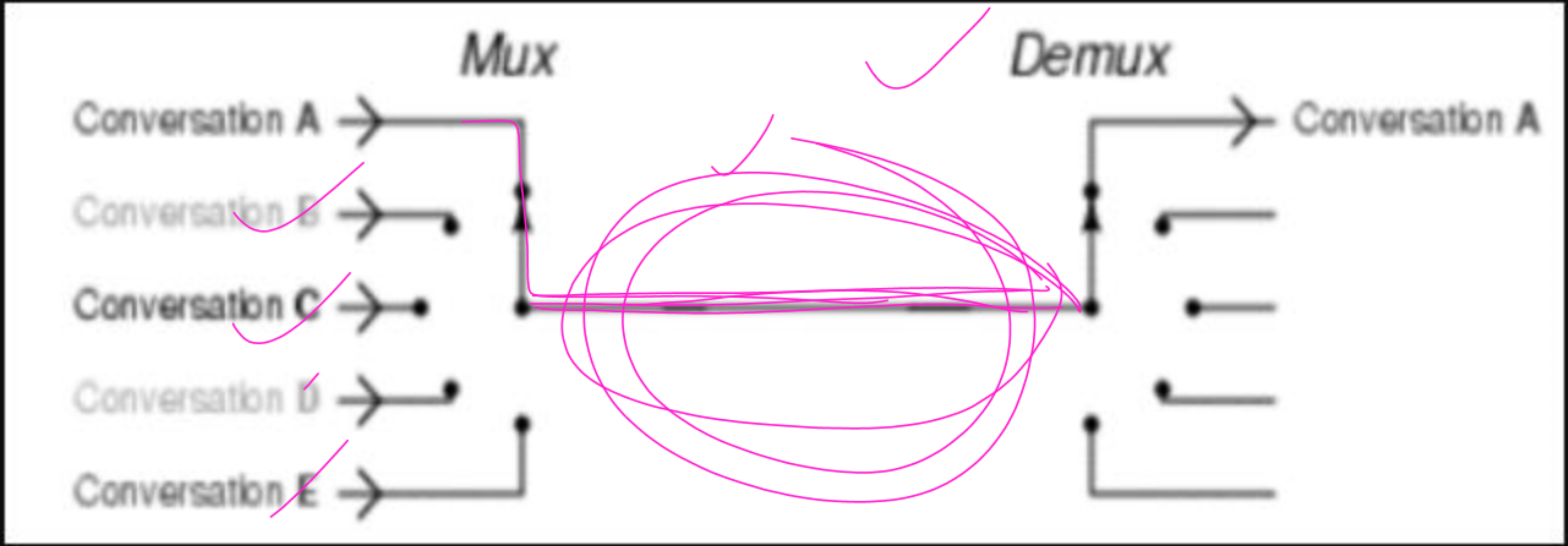
$$f_{LSB} = f_c - f_m = 10^5 - 10^3 = 99000 \text{ Htz}$$

# MULTIPLEXING

- **(TDM)Time Division Multiplexing**

TDMA
FDMA
CDMA

**In this multiplexing we split the data exchange time into multiple small slots and transmit/receive different data onto different slot. The time frame is divided into slots. This technique is used to transmit a signal over a single communication channel, with allotting one slot for each message.**



## CDMA

- In CDMA, all the stations can transmit data simultaneously. It allows each station to transmit data over the entire frequency all the time. Multiple simultaneous transmissions are separated by unique code sequence. Each user is assigned with a unique code sequence. When CDM is used to allow multiple users to share a single communications channel, the technology is called code division multiple access (CDMA).

- Code Division Multiple Access system is very different from time and frequency multiplexing. In this system, a user has access to the whole bandwidth for the entire duration.

## WORKING OF CDMA

- In this technique, we split a communication channel into different code and allocate each stream of data onto different code.

- CDMA means data can be sent in small pieces over a number of frequencies available to use at any time in the specified range.

## Frequency Division Multiple Access

- FDMA is a type of channelization protocol. In this bandwidth is divided into various frequency bands. Each station is allocated with band to send data and that band is reserved for particular station for all the time

# EVOLUTION OF MOBILE COMMUNICATION

## 1G – First generation mobile communication system

- Key features (technology) of 1G system
- Frequency 800 MHz and 900 MHz
- Bandwidth: 10 MHz (666 duplex channels with bandwidth of 30 KHz)
- Technology: Analogue switching
- Modulation: Frequency Modulation (FM)
- Mode of service: voice only
- Access technique: Frequency Division Multiple Access (FDMA)

# 2G – Second generation communication system (GSM)

- Digital system (switching)
- SMS services is possible
- Roaming is possible
- Enhanced security
- Encrypted voice transmission
- First internet at lower data rate
- Disadvantages of 2G system
- Low data rate
- Limited mobility
- Less features on mobile devices
- Limited number of users and hardware capability

## 2.5 G and 2.75G system

- In order to support higher data rate, General Packet Radio Service (GPRS) was introduced and successfully deployed. GPRS was capable of data rate up to 171kbps (maximum).
- EDGE – Enhanced Data GSM Evolution also developed to improve data rate for GSM networks. EDGE was capable to support up to 473.6kbps (maximum).
- Another popular technology CDMA2000 was also introduced to support higher data rate for CDMA networks. This technology has the ability to provide up to 384 kbps data rate (maximum).

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# 3G – Third generation communication (UMTS) system

- Higher data rate
- Video calling
- Enhanced security, more number of users and coverage
- Mobile app support
- Multimedia message support
- Location tracking and maps
- Better web browsing
- TV streaming
- High quality 3D games

# 3.5G to 3.75 Systems

- In order to enhance data rate in existing 3G networks, another two technology improvements are introduced to network. HSDPA – High Speed Downlink Packet access and HSUPA – High Speed Uplink Packet Access, developed and deployed to the 3G networks. 3.5G network can support up to 2mbps data rate.
- 3.75 system is an improved version of 3G network with HSPA+ High Speed Packet Access plus. Later this system will evolve into more powerful 3.9G system known as LTE (Long Term Evolution).

$H^+$ LTE

# 4G – Fourth generation communication system

- Much higher data rate up to 1Gbps
- Enhanced security and mobility
- Reduced latency for mission critical applications
- High definition video streaming and gaming
- Voice over LTE network VoLTE (use IP packets for voice)

① Satellite Communication

② Radar Communication

| Generation | Speed | Technology | Key Features |
|---|---|---|---|
| 1G (1970 –1980s) | 14.4 Kbps | AMPS,NMT, TACS | Voice only services |
| 2G (1990 to 2000) | 9.6/ 14.4 Kbps | TDMA,CDMA | Voice and Data services |
| 2.5G to 2.75G (2001-2004 ) | 171.2 Kbps 20-40 Kbps | GPRS Edge | Voice, Data and web mobile internet, low speed streaming services and email services. |
| 3G (2004-2005) | 3.1 Mbps 500- 700 Kbps | CDMA2000 (1xRTT, EVDO) UMTS and EDGE | Voice, Data, Multimedia, support for smart phone applications, faster web browsing, video calling and TV streaming. |
| 3.5G (2006-2010) | 14.4 Mbps 1-3 Mbps | HSPA HT | All the services from 3G network with enhanced speed and more mobility. |
| 4G (2010 onwards) | 100-300 Mbps. 3-5 Mbps 100 Mbps (Wi-Fi) | WiMax, LTE and Wi-Fi Vo-LTE | High speed, high quality voice over IP, HD multimedia streaming, 3D gamming, HD video conferencing and worldwide roaming. |
| 5G (Expecting at the end of 2019) | 1 to 10 Gbps | LTE advanced schemes, OMA and NOMA | Super fast mobile internet, low latency network for mission critical applications, Internet of Things, security and surveillance, HD multimedia streaming, autonomous driving, smart healthcare applications. |