Introduction to communication system

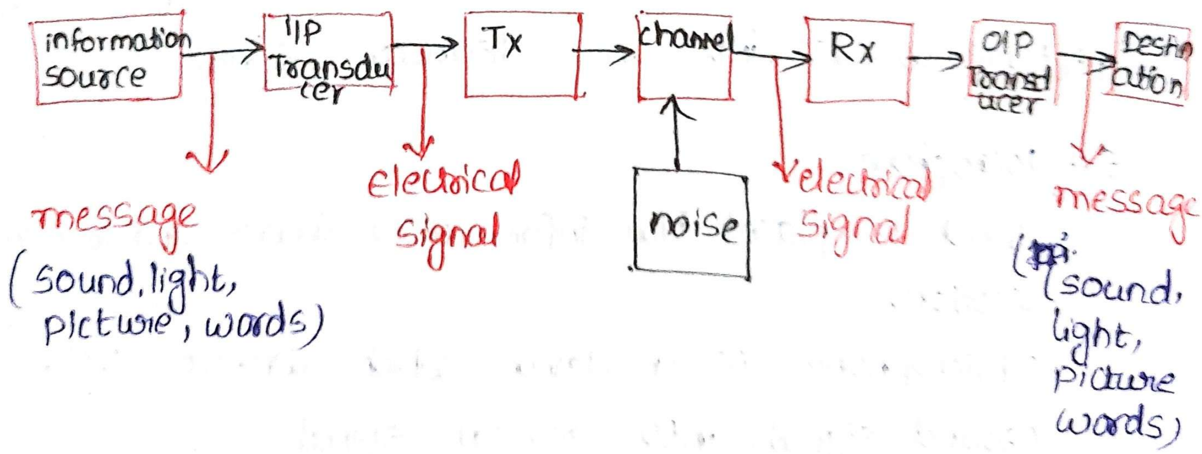
→ communication means sending, receiving and processing of information between two or more devices.

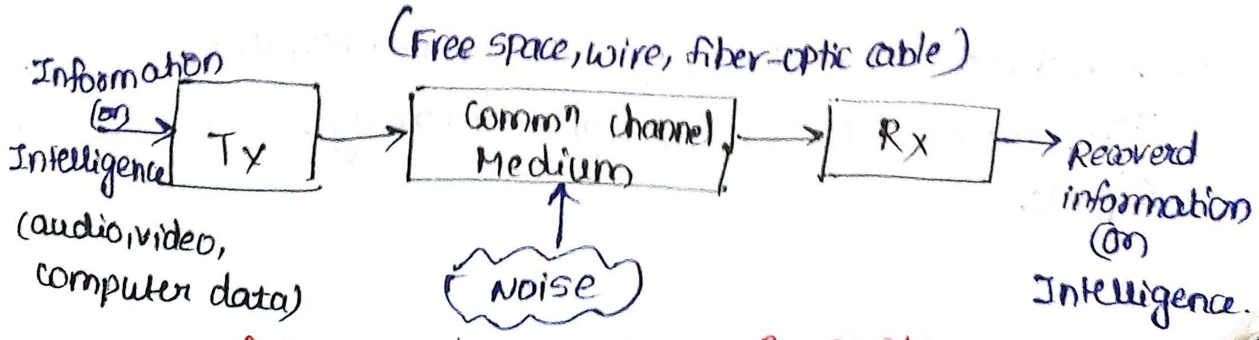
→ A collection of elements (devices) which works together to establish a comm^n b/w the sender and the receiver is called a "comm^n system"

Ex:- Radio Broadcasting, TV Broadcasting, Radio Telegraphy, mobile comm^n, computer comm^n

→ Two or more people communicating with each other by using sound signals are also known as the comm^n system.

Block Diagram of Comm^n system :





A general model of com^n systems.

The basic components of commn system are information source, i/p transducer, transmitter, commn channel, Receiver, o/p Transducer, destination.

Information Source :-

→ Information originates in the information source.

→ The information generated by the source may be in the form of sound (human speech), picture (image source), words (plain Text).

→ The message is referred to as information or an intelligence signal.

I/p Transducer :-

Transducer is a device which converts one form of energy or signal into another form of energy or signal.

→ I/p transducer converts non-electrical signal (sound, picture, words) into an electrical signal.

Ex: Microphone.

∴ which is placed b/w information source and transmitter section.

→ Microphone is a device which converts voice signal (sound signal) into electrical signal.

→ Transducer converts physical characteristics (temperature, pressure, light intensity...) into electrical signals.

Transmitter :-

Transmitter is a device, which transmits the message (electronic signal) over the commn channel.

→ Transmitter use a technique called modulation to send the signals to larger distances.

→ Modulation increases the strength of a signal without changing the parameters of the original signal.

→ Transmitters are made up of oscillators, amplifiers, tuned circuits filters, modulators, freq. mixers, freq. synthesizers

Communication channel :-

→ The commn channel is a medium through which the signal travels.

→ The commn channel is a wired or wireless medium through which the signal (information) travels from source (transmitter) to destination (Receiver).

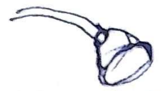
→ The commn channel is a wired or wireless medium that connects the transmitter and receiver for sending the signal.

Wired channels :- co-axial cables, fiber optic cables, twisted pair telephone lines.

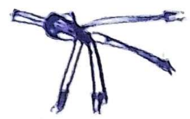
Wireless channels :- air, water, vaccum

→ Along the way, noise is added in the commn channel.

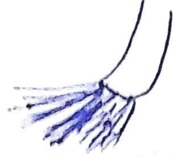
→ Noise is the general term applied to any phenomenon that degrades or interferes with the transmitted information.



co-axial cables



Twisted-pair cables.



fiber-optic cable.

Receiver :-

The receiver is a device that receives the signal (electrical signal) from the channel and converts signal back to original form (light or sound).

EX: TV

TV Receives signals sent by the TV transmitting station and converts the signal into a form which is understanding by the humans who are watching T.V.

→ Receivers contains amplifiers, oscillators, Mixers, tuned circuits, filters, demodutor, detector

O/P Transducer :-

O/P Transducer converts electrical signal to non-electrical signal (sound or light)

EX:- Loud speaker.

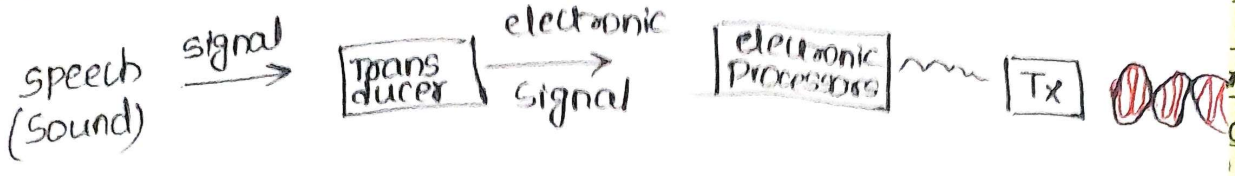
Loudspeaker converts the electrical signals into sound signals which are easily understand by humans at the destination.

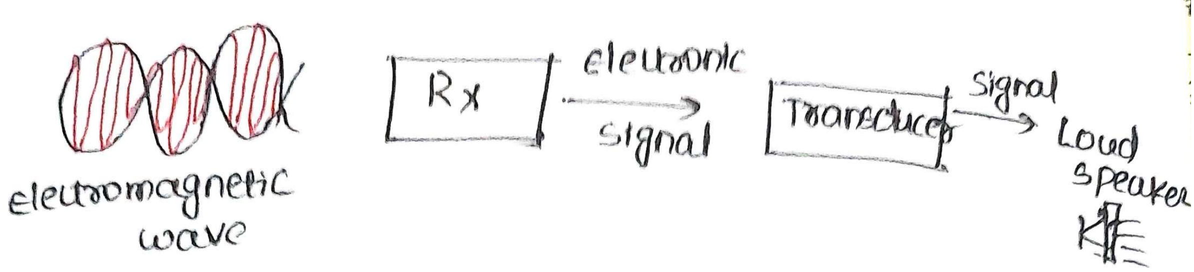
Destination :-

The final stage in the commn system.

→ A destination is a place where human consumes the information.

Ex: watching T.V.





An electronic commn system using electronic signals.

Transceivers

Most commn equipments incorporates circuits that both send and receiver. These are referred as "Transceivers"

→ so both electronic commn is two-way, both a transmitter Tx and Receiver Rx.

Ex:- Telephones, fax Machines, hand-held CB radio's cellular Telephones, computer modems.

$\boxed{\text{Transceiver} \longrightarrow \text{Transmitter} + \text{Receiver.}}$

Noise :-

The measure of noise is expressed interms of S/N ratio Signal to Noise Ratio (SNR), which is

$$\boxed{SNR = \frac{\text{Signal power}}{\text{Noise power.}}} \quad (dB).$$

→ High SNR, preferred for best performance.

Modulation

Modulation and Multiplexing are electronic techniques for transmitting information efficiently from one place to another.

→ Modulation makes the information signal more compatible with the medium

→ Multiplexing allows more than one signal to be transmitted concurrently over a single medium.

→ The original information or intelligence signals are analog or digital referred as BaseBand signals.

↓ Message signal.

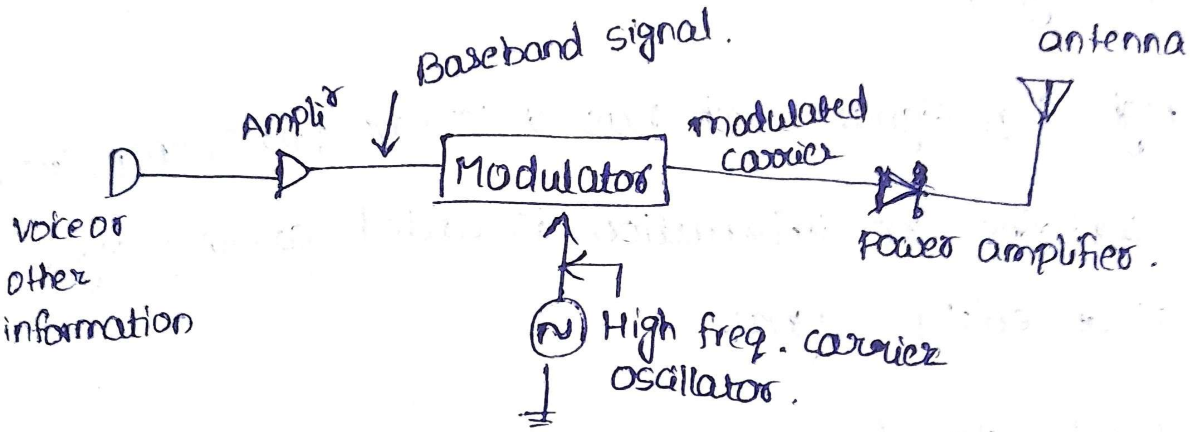
→ The baseband signals are incompatible for direct transmission. , to travel longer distances, its strength has to be increased by modulating with high freq. carrier wave which doesn't effect the parameters of the modulating signal.

→ Modulation is the process of having a baseband (voice, video, digital) signal, modify carrier signal (High freq. signal). The information to be sent is said to be "impressed" upon a carrier. , the information signal changes the carrier in a unique way.

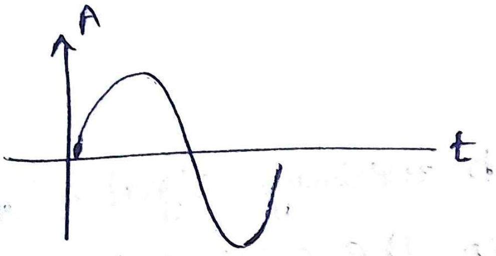
→ the modulated carrier is amplified and sent to the antenna for transmission. This process is called "BaseBand Transmission"

Modulation :-

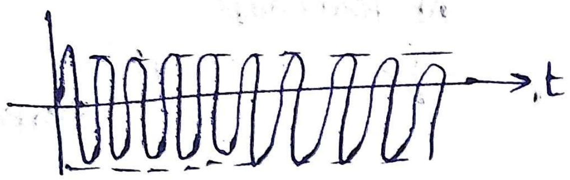
Modulation is the process of changing the parameters of the carrier signal, in accordance with the instantaneous values of modulating signal.



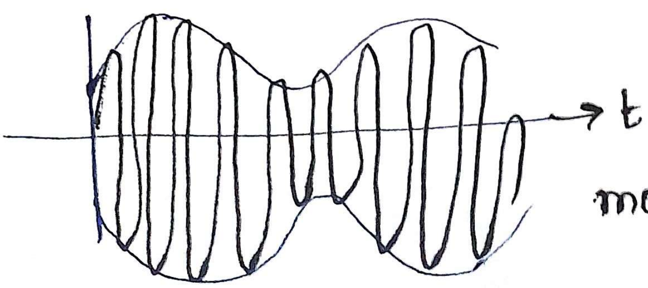
Modulation at the transmitter side.



message or Information or modulating wave.



carrier wave



modulated-wave

→ Modulating signal

The signal which contains a message to be transmitted is called modulating signal or message signal.

→ carrier signal

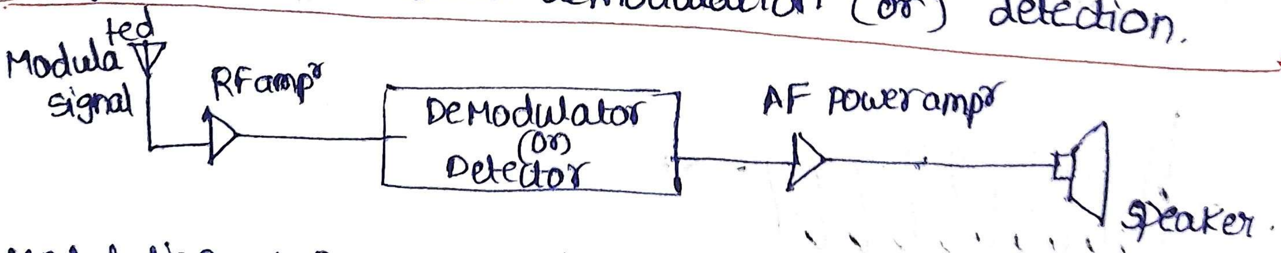
The high freq. signal which has a certain phase, freq, ampli but contains no information is called carrier signal

→ It is an empty signal.

→ Modulated signal

The resultant signal after the process of modulation is called as modulated signal.

→ At the receiver, the carrier with message signal is amplified and then demodulated to extract the original base band signal. which is called demodulation (or) detection.



DeModulation at Receiver side.

Need for Modulation :-

1. Reduction in the height of antenna
2. Avoids mixing of signals
3. Increases the range of $comm^n$
4. Multiplexing is possible
5. Improves quality of reception.

1) Reduction in the height of antenna :-

For the transmission of radio signals, antenna height must be multiple of $\boxed{\lambda/4 = H}$

where λ = wavelength

$$\boxed{\lambda = c/f}$$

c = velocity of light. $= 3\times10^8$ m/s.

f = freq. of the signal to be transmitted

Ex:- Baseband signal of $f = 15$ KHz, calculate minm antenna height required to transmit.

$$\lambda = c/f = \frac{3\times10^8}{15\times10^3} = 20000 \text{ m}$$

$$H = \lambda/4 = \frac{20000}{4} = 5000 \text{ meters}$$

→ Antenna height is practically impossible to install. Hence High freq. carrier signal is imparts on low freq. message signal.

consider Modulated signal at f = 1 MHz, calculate minimum antenna height.

$$H = \frac{\lambda}{4} = \frac{c}{f \times 4} = \frac{3 \times 10^8}{1 \times 10^6 \times 4} = 75\ m.$$

→ Hence, to reduce the antenna height, modulation is needed.

2. Avoids mixing of signals :-

→ If the baseband sound signals (freq. range 0-20KHz) are transmitted without using modulation by more than one transmitter, all the signals get mixed together and a receiver cannot seperate them from each other.

→ Hence, each baseband sound signal is used to modulate a different carrier then they will occupy different slots in the freq. domain (different channels).

Thus modulation avoids mixing of signals.

3. Increase the range of commn

→ The low freq. baseband signals cannot travel long distance when they are transmitted.

They get heavily attenuated.

→ The attenuation reduced with increase in freq. of the transmitted signal, and they travel longer distance.

→ the modulation process increases the freq. of the signal to be transmitted.

Therefore, it increases the range of commn.

4. Multiplexing is possible

Multiplexing allows more than one signal to be transmitted concurrently over a single medium.

→ It is possible only with modulation.

→ Many TV channels can use the same freq. range without getting mixed with each other or different freq. signals can be transmitted at the same time.

5. Improves quality of reception :-

High freq. carrier signal, protect information from various disturbances and will get information without any loss. This improves quality of reception.

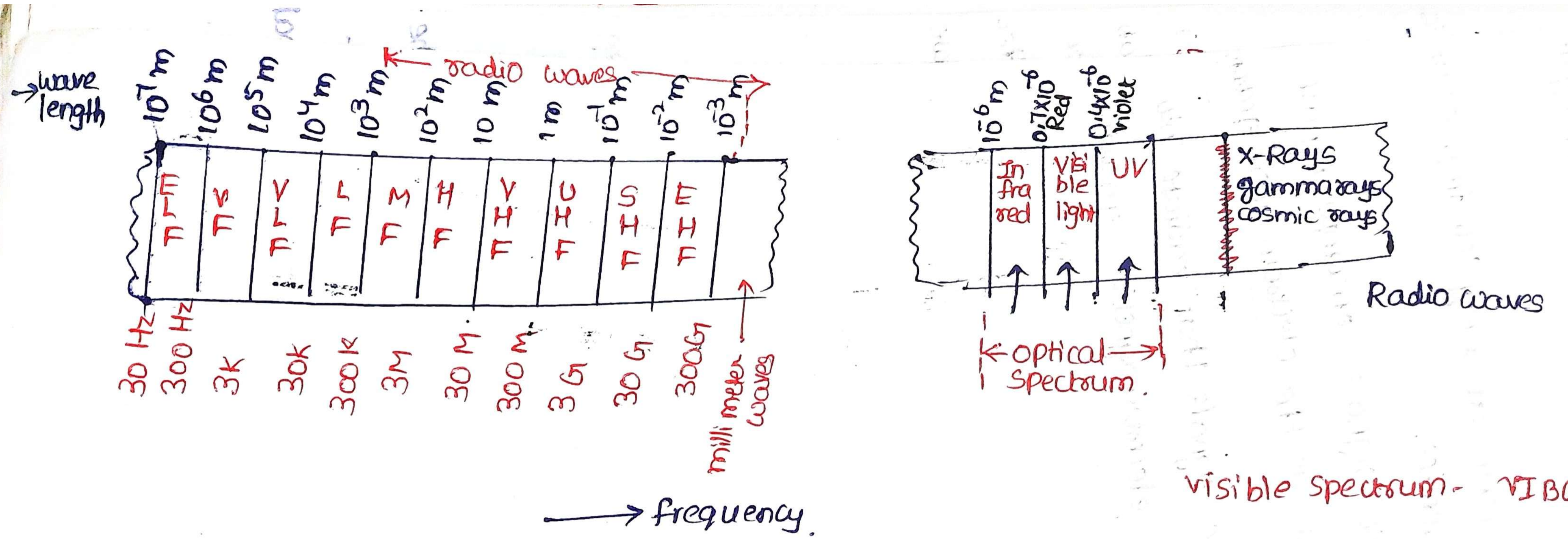
:- electromagnetic spectrum :-

Electromagnetic waves are signals that oscillates i.e. amplitudes of the electric and magnetic fields vary at a specific rate.

→ These oscillations may occur at a very low freq. or at an extremely high frequencies.

→ The range of electromagnetic signals encompassing all frequencies is referred to as the electromagnetic spectrum

→ All electrical and electronic signals that radiate into free space fall into the electromagnetic spectrum.



Electromagnetic Spectrum.

visible spectrum - VIBGYOR.

Electromagnetic spectrum used in electronic commⁿ

Name	freq	wavelength
ELF- Extremely low frequencies	30-300 Hz	$10^7 - 10^6$ m
Voice Frequencies (VF)	300 - 3000 Hz	$10^6 - 10^5$ m
Very Low Frequencies (VLF)	3 K - 30 K	$10^5 - 10^4$ m
Low Frequencies (LF)	30K - 300K	$10^4 - 10^3$ m
Medium Frequencies (MF)	300K - 3 M.	$10^3 - 10^2$ m
High Frequencies (HF)	3 M - 30 M	$10^2 - 10$ m
Very High Frequencies (VHF)	30 - 300 M	10 - 1 m
Ultra High Frequencies. (UHF)	300M - 3G	$1 - 10^{-1}$ m
Super High Frequencies (SHF)	3G - 30 G	$10^{-1} - 10^{-2}$ m
Extremely High Frequencies (EHF)	30 G - 300 G	$10^{-2} - 10^{-3}$ m
Infrared.	~~3~~ -	0.7 - 10 μm
Visible spectrum (light)	-	0.4 - 0.8 μm

10^3 - 1K.

10^6 - 1 M

10^9 - 1G

10^{12} - 1T.

ELF : extremely Low Frequencies :- 30 - 300 Hz

→ These include ac power line frequencies (50 and 60 Hz) as well as those frequencies in the low end of the human audio range.

VF :- Voice Frequencies → normal range of human speech.

VLF :- Higher end of human hearing range.

Many musical instruments make sounds in this range

→ used some government and military commn.

LF :→ Aeronautical & marine navigation.

→ also used as subcarriers

MF → AM Broadcasting.

→ Aeronautical & marine commn

HF → Known as short waves (3M - 30 MHz).

→ All kinds of simplex broadcasting and half-duplex two-way radio commn

→ Broad casts from voice of America and BBC (British Broadcasting Company) occurs in this range.

→ Embassies, Amateur radio, CB Commn.

Amateur radio ↓ Individuals may become licensed "hams" to build and operate two-way radio equipment for personal commn with other hams.

CB ↓ Citizen Band Radio.

↳ used in trucks and cars to exchanging the information about traffic conditions, speed traps and emergencies.

VHF → Mobile Radio, marine and auronautical commn, FM radio Broadcasting, (88 M - 108 MHz), TV channels (~~2 M - 13 M~~ (2 through 13). Radio amateurs also have numerous bands.

UHF → TV channels 14 through 67

→ Land mobile commn

→ cellular Telephones, military commn.

→ some radar and navigation services.

→ Radio amateurs also have bands.

Microwave and SHF :-

1G - 30 GHz → Microwaves.

→ Microwave ovens (2.45 GHz)

3 to 30 GHz → SHF.

→ satellite commn & Radars.

→ Wireless LAN.

EHF → satellite commn, Telephony, computer data specialized radar.

→ Equipment used to generate and receive signals are extremely complex and expensive.

millimeter waves :- This spectrum is virtually info uninhabited.

→ It is a cross between RF and optical.
→ Lack of Hardware and components prevents its use.

The optical spectrum :- occupied by light waves.

→ 3 types of light waves.

1) Infrared
2) visible
3) ultra-voilet.

Infrared :- Infrared is produced by light bulbs, our bodies, LED's and Lasers.

Uses → Astronomies to detect stars, universe, guidance in weapons systems, guides missi to target

→ new TV remote-control units
→ optical devices such as lenses and mirrors c often used to manipulate Infrared signals c infrared lights propagated over fiber-optic c

Visible Spectrum :- Light
Laser

Ultra-voilet spectrum (UV) :-
→ generated by sun causes sunburn.
→ generated by Mercury vapor lights

Gain, Attenuation, and Decibels :-

Most electronic circuits in common are used to process signals i.e. to manipulate signals to produce a desired result. All signal processing circuits involve either gain or attenuation.

Gain :-

Gain means amplification.

→ If the signal is applied to a circuit such as the amplifier and the o/p of the circuit has a greater amplitude than the i/p signal, the circuit has Gain.

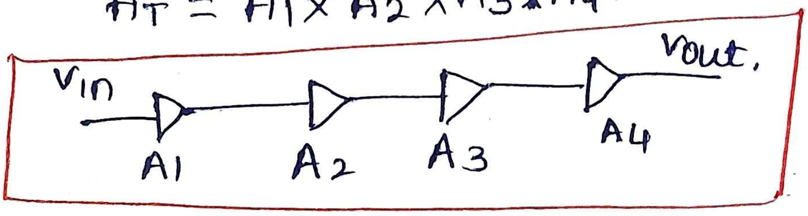
→ Gain is the ratio of output to the input.

$$\boxed{\text{voltage gain} = \frac{\text{o/p voltage}}{\text{i/p voltage}} = \frac{V_o}{V_{in}} = A_V.}$$

⇒ $$\boxed{\text{power gain} = \frac{\text{o/p power}}{\text{i/p power}} = \frac{P_{out}}{P_{in}} = A_P.}$$

→ when two or more stages of amplification or other forms of signal. processing are cascaded, the over all gain of the combination is the product of the individual circuit gains.

$$A_T = A_1 \times A_2 \times A_3 \times A_4.$$



Attenuation :-

Attenuation refers to a loss introduced by a circuit or component.

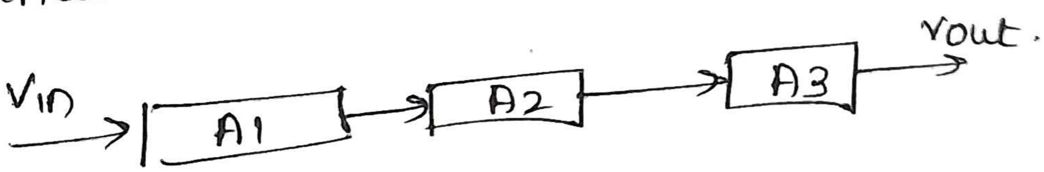
→ Many electronic circuits, sometimes called stages, reduce the amplitude of a signal rather than increase it.

→ If the o/p signal is lower in amplitude than the i/p, the circuit has loss or attenuation.

$$\text{Attenuation} \quad A = \frac{o/p}{i/p} = \frac{V_{out}}{V_{in}}$$

→ Circuits that introduce attenuation have a gain that is less than 1.

→ Total attenuation is the product of individual attenuations of each cascaded circuit.



$$\boxed{A_T = A_1 \times A_2 \times A_3}$$

Decibels :-

→ The gain or loss of a circuit is usually expressed in decibels (dB).

→ A unit of measurement that was originally created as a way of expressing the hearing response of human ear to various sound levels.

→ The decibel is one-tenth of bel   Deci → 10.

Decibel calculations :-

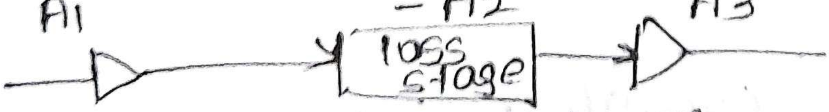
$$dB = 20 \log \frac{V_{out}}{V_{in}}$$

$$dB = 20 \log \frac{I_{out}}{I_{in}}$$

$$dB = 10 \log \frac{P_{out}}{P_{in}}$$

→ Total gain or attenuation is the algebraic sum of the individual stage gains in decibels.

Ex :



$$\boxed{A_T = A_1 - A_2 + A_3}$$

Ex- Express Pout = 12.3 dBm in watts.

$$\frac{P_{out}}{0.001} = 10^{dBm/10}$$

$$= 10^{12.3/10}$$

$$= 10^{1.23}$$

$$= 17.$$

$$\boxed{P_{out} = 0.01 \times 17 = 17\,mW}$$

Ex Amplifier has power gain of 28 dB. i/p power is 36mW what is the o/p power.

$$\text{power gain} = 28\ dB = \frac{P_{out}}{P_{in}} = \frac{P_{out}}{36\,mW} = 10^{dB/10}$$

$$\frac{P_{out}}{36\,mW} = 10^{28/10}$$

$$= 10^{2.8}$$

$$\frac{P_{out}}{P_{in}} = 630.96$$

$$P_{out} = 630.96 * 36\,mW.$$

$$\boxed{P_{out} = 22.71\,W}$$

Anti log :-

The antilog is the number obtained when the base is raised to the logarithm which is exponent.

$$dB = 10 \log \frac{P_{out}}{P_{in}}$$

$$\frac{dB}{10} = \log \frac{P_{out}}{P_{in}}$$

$$\frac{P_{out}}{P_{in}} = \text{antilog } \frac{dB}{10}$$

$$= \text{antilog } dB/10$$

$$\frac{P_{out}}{P_{in}} = \log^{-1} \frac{dB}{10}$$

antilog is simply the base 10 raised to the $\frac{dB}{10}$ Pa

Note :- 0 dB → is the least perceptible sound (hearing threshold).

120 dB → Pain threshold of sound.

Sound	Intensity level (dB)
hearing threshold	0.
~~Ras~~ Rustling leaves	10
whisper	20
Quiet Radio	40
Normal conversation	65
Busy street corner	80
Subway car	100
Pain Threshold	120
Jet engine	140 – 160

Frequency Translation :

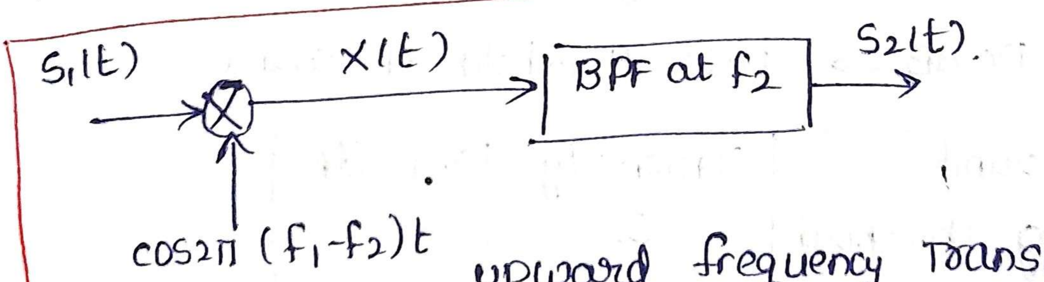
The process of transferring a signal from one part of the frequency axis to the other is called frequency Translation.

→ It occurs frequently in a wireless commⁿ systems, that is frequency translation is used to transfer the pass band signal to base band signal.

→ The Decimation is the most efficient method of the frequency translation.

Ex:- consider a modulated signal $S_1(t)$ with a centred spectrum of frequency f_1 and a factor of $\cos 2\pi(f_2-f_1)t$.

where f_2 is the centred spectrum of frequency of Band pass filter.

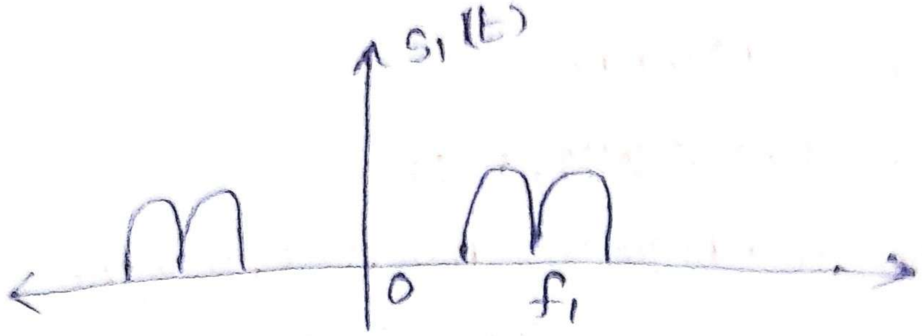


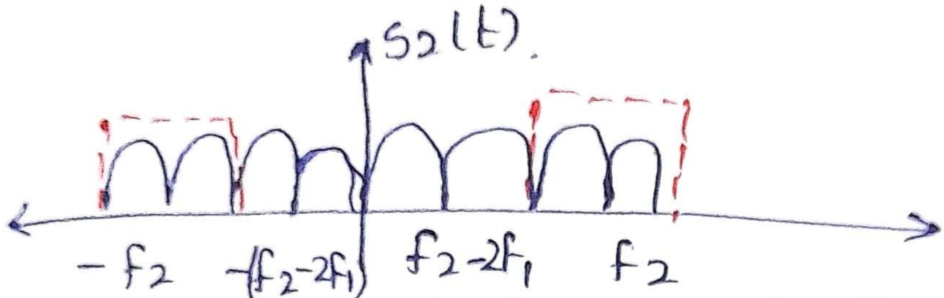
upward frequency Translation

$x(t)$ signal can be obtained by the multiplication of signal $S_1(t)$ with $\cos 2\pi(f_1-f_2)t$.

→ The resultant signal $x(t)$ is passed through the Band Pass Filter which is a centreed spectrum of frequency f_2.

The BPF output results as an upward frequency translated signal $S_2(t)$.





O/P response of BPF

→ The signal $S_1(t)$ represents with a centred spectrum of frequency f_1 and o/p of BPF results in an upward translated frequency signal $S_2(t)$.

→ Similarly, the downward frequency translation is estimated by multiplying the modulated signal with $\cos 2\pi (f_2-f_1)t$ and the filtering out the high frequency component using the lower frequency component.