Data Communication :→

→ Communication in the form of signal day to day live ex. sound

→ Analog in nature

→ for Long distance Analog signals are sent through wire,

Why to digitize :→ Analog signals for long distance communications suffer from many losses such as distortion, interference and other losses. including less security.

Advantages of Digital communication: over analog Comm^n

→ Distortion, noise and interference is much less.

→ Dig. ckts are more reliable

→ Dig ckts. are easy to Design and cheaper

→ H/W implementation is flexible

→ Cross talk is less

→ More Security due to Encryption ~~and~~.

→ Spread spectrum tech. can be used to avoid signal Jamming.

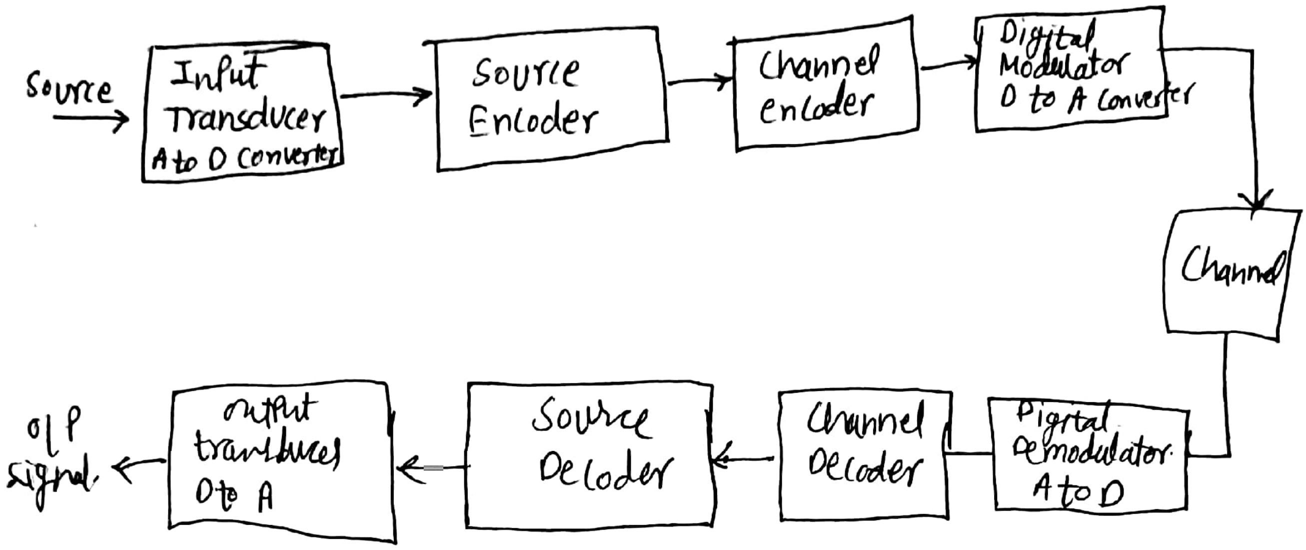
→ Configuring process is easier

→ Can be save

→ due to encoding similar device can be used for a no. of purposes.

→ The capacity of the channel is effectively utilized.

Elements of Digital Communication.



- → Source : analog signal ex : sound signal
- → I/P Trans. : convert input to an electrical signal (Ex : Microphone)
  A to D : Digital sig. is generally represented by a binary seq.
- → Source Encoder : compress the data into minimum no. of bits. for effective utilisation of B/W. Remove redundant bits.
- → Channel encoder : does coding for error detection as noise can altered the signal.
- → Digital Modulator : signal to be transmitted is modulated here by a carrier. signal is also converted to analog ~~form~~ from dig. seq. in order to travel through medium.
- → Channel : → Medium, allows signal to transmit
- → Digital Demodulator : Received signal is Demodulated and converted again from analog to digital. The signal gets reconstructed
- → Channel Decoder : → does some error correction
- → Source Decoder : → signal is digitized again by sampling and quantisation

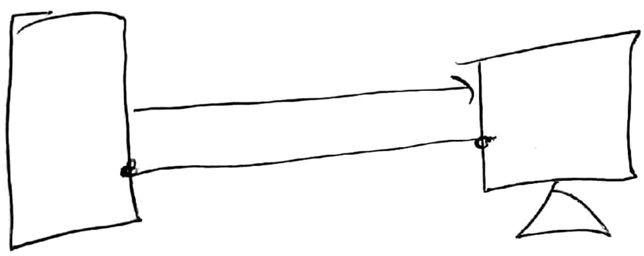
Transducer : Physical I/P to Electrical and vice versa

output Transducer : → converts electrical signal into Physical signal

Transmission Mode
Data Flow : →
- → Simplex
- → Half - Duplex
- → Full Duplex.

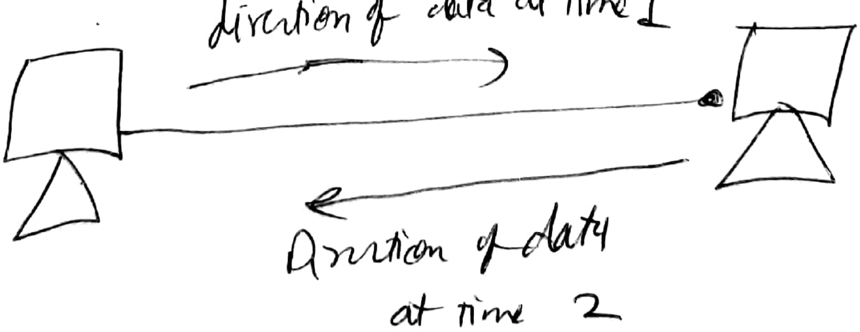
Data transmission mode is used to define the direction of signal flow b/w two linked devices.

- 1) Simplex : → Unidirectional , one way street. ex: keyboard.



Simplex

- 2) Half duplex : → Both stations can transmit and receive , but not at the same time.
  ex: walkie - talkies



3) Full Duplex :→ Both stations can transmit and receive simultaneously. Two way street. ex. Mobile Phone.

Data communication: Exchange of data (in 0 or 1) between two devices. via some form of transmission medium.

→ Two types

1) Local : Same building

2) ~~Geographical~~ Remote : → If devices are farther apart.

Characteristics of Data comm :→

Effectiveness of Data communication dependent on three fundamental charact.

1) Delivery :→ Delivers data to correct Destination.

2) Accuracy :→ System must Deliver Data accurately.

3) Timeliness :→ Must Deliver data in time, Data delivered late are useless.

Components of Data Communication :→

1) Message :→ information to be communicated can be text, number, Picture, sound, Video etc.

2) Sender :→ Device that sends the data message. can be computer, work station, telephone, TV.

3) Medium :→ Physical Path for data travelling. can be wired or wireless.

4) Receiver → Device that receive the message can be computer, workstation, TV etc.

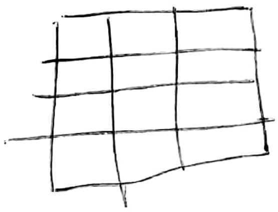
5) Protocol :→ A set of rules that govern data communication. It represents an agreement between the communicating devices.
without protocol device can be connected but can not communicate
for ex: one understand Hindi and other french.

Data Representation :→ can be represented by

1) Text: A, B, etc. → text have ASCII code.
ASCII code is decimal no.
ex code of A = 66 then 66 will be converted to Binary.

2) Numbers :→ 12, 13, 677, etc. No. do not have ASCII code, directly to Binary.
can be binary, octal, decimal, hexadecimal etc.

3) Images :→



4) Audio :→

5) Video :→ Moving pictures are video.

Signals :→ Generally information usable to Person or application is not in a form that can be transmitted over a network. ex. You can't roll up a Photograph. insert in a wire and transmit it across.

→ we can However transmit an encoded description of the Photograph. in 0 or 1.

→ But even 1 and 0 can not be sent as such across network link. They must be further converted into a form that transmission media can accept. so 1 and 0 must be turned into energy in the form of electromagnetic signals.

- Analog and Digital :→

Analog → something that is continuous. means a set of specific points of data and all possible points between.

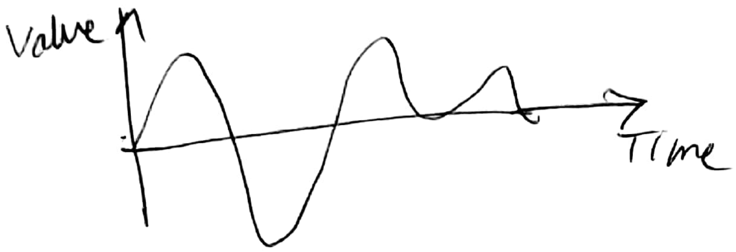
Digital :→ that is Discrete means a set of specific Points of data with no other Points in between.

- Analog and Digital Data :→ ex. of Analog data is human voice. which is continuous wave.

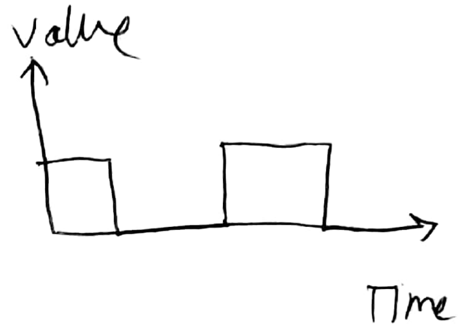
example of digital data is data stored in memory of computer in the form of 0 and 1. It is usually converted to digital signal when it is transferred from one Position to another.

$$\text{Data} \xrightarrow{\text{transform}} \text{Signal}$$

Analog and Digital signal :→ Analog signals can have any value in range
Digital signals can have only a limited no. of values.



a) Analog Signal



b) Digital signal.

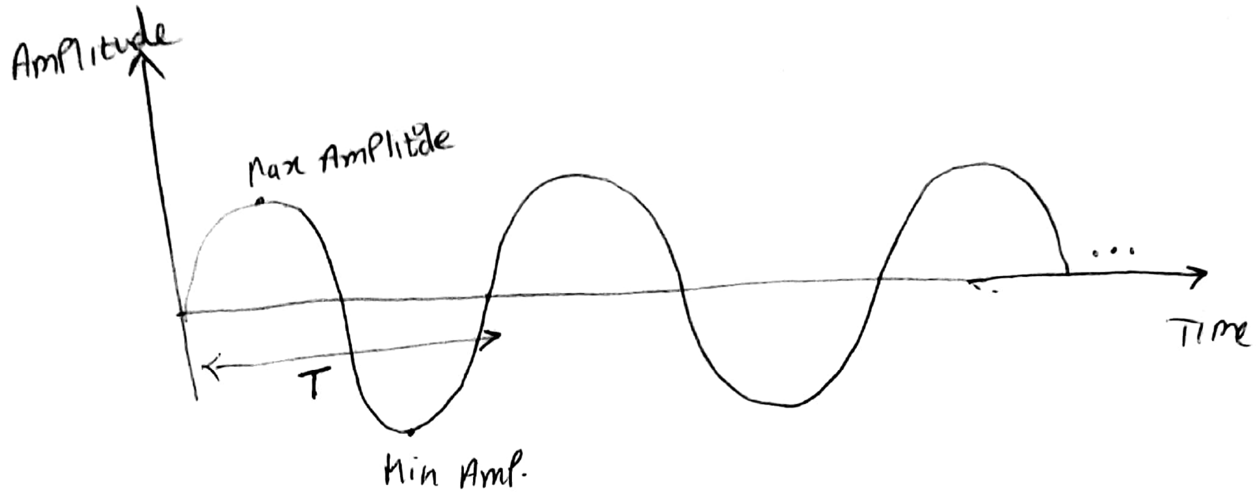
Both analog and Digital Signal can be Periodic or Aperiodic.

Analog signals:→ Two types : simple or composite.
Simple or sine wave : Can not be decomposed into simples signal.
Composite :→ composed of multiple sine waves.

1) Simple or sine wave :→ Can be fully describe by three characteristics : amplitude, Period or frequency, and Phase.

Amplitude :→ Refers to the height of the signal. Unit depends on type of signal. ex volts, Amp. etc.

Period and freq :→ Amount of time, time required to complete one cycle. Freq is no. of Period in one sec.



Unit of Period :→

Unit	Equivalent
Second	1 Sec
(ms) Milisecond	10^{-3} Sec
(μs) Micro Second	10^{-6} Sec
(ns) Nano seconds	10^{-9} sec
(Ps) Pico seconds	10^{-12} sec

Ex 1 : Show 100ms in sec, microseconds, nano second and Pico seconds.

Ans : 0.1 sec, 10^{5} μs, 10^{8} ns, 10^{11} Ps

Unit of Freq :→

Unit	Equivalent
Hz (Hertz)	1 Hz
KHz (KiloHz)	10^{3} Hz
MHz (Mega Hertz)	10^{6} Hz
GHz (Giga hertz)	10^{9} Hz
THz (Tera Hz)	10^{12} Hz

Ex: 2

Show 14MHz in Hz, KHz, GHz, and THz

Ans : 14×10^{6} Hz, 14×10^{3} KHz, 14×10^{-3} GHz, 14×10^{-6} THz

Converting Freq to Period and vice versa:

Ex: 3 : A sine wave has a freq of 6 Hz. find Period.

$T = 1/f = 1/6 = 0.17$ sec.

Ex: 4 : $f = 8$ KHz , $T = ?$

$T = 125 \mu s$.

Ex: 5 : A sine wave completes one cycle in 4 sec. find f.

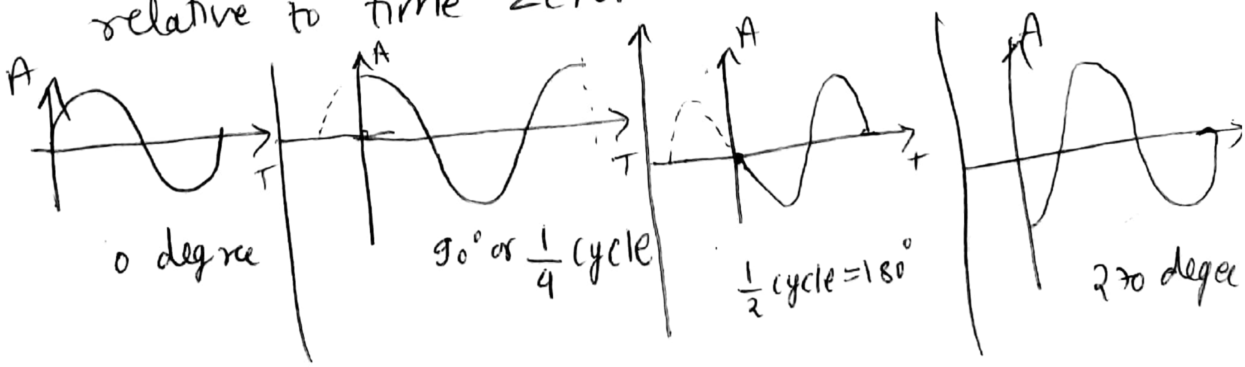
$$f = \frac{1}{T} = \frac{1}{4} = 0.25 \text{ Hz}$$

Ex: 6 : A wave completes one cycle in $25 \mu s$. Find f.

$f = 1/T = 1/25 \times 10^{-6} = 40$ KHz

Two Extrems of Freq : → $f = 0$, if signal does not change at all.
$f = \infty$, if signal changes instantaneously.

Phase: → Describes the Position of the waveform relative to time zero.



Ex: A sine wave is offset 1/6 of a cycle wit respect to time zero. what is its Phase ?

$$\cdot\ 1 \text{ cycle} = 360^\circ$$

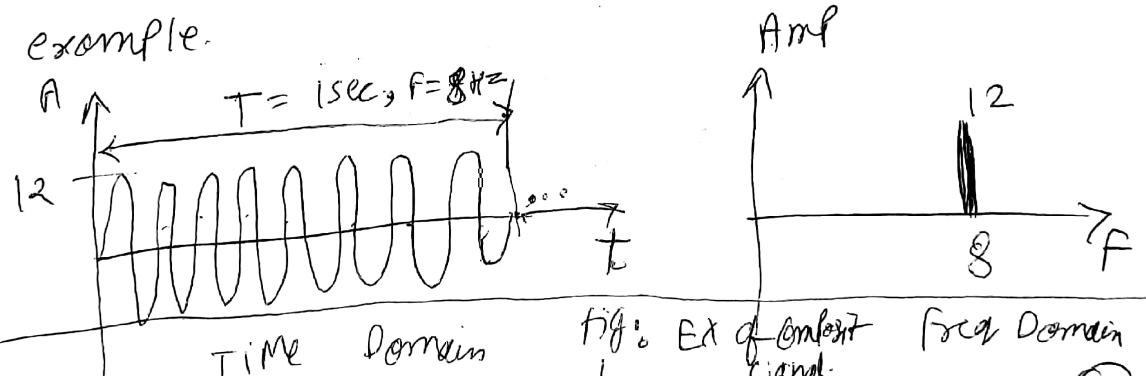
$$\therefore\ \frac{1}{6} \text{ cycles} = 360 \times \frac{1}{6} = 60^\circ$$

Composite signals: → Any Periodic Signal, no matter how complex, can be decomposed into a collection of sine waves,

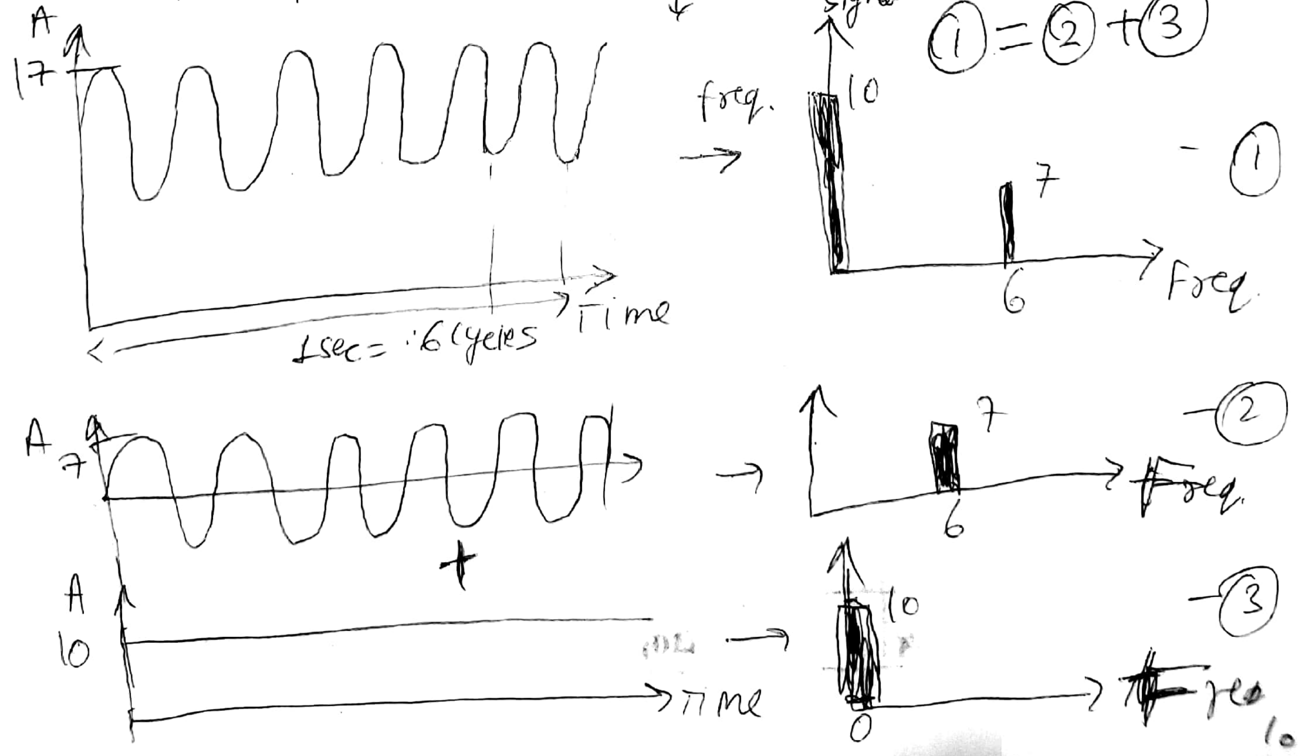
→ To Decompose a composite signal into its components, Fourier analysis is needed.

- Time Domain and frequency Domain : → relationship b/w Amp. and freq.

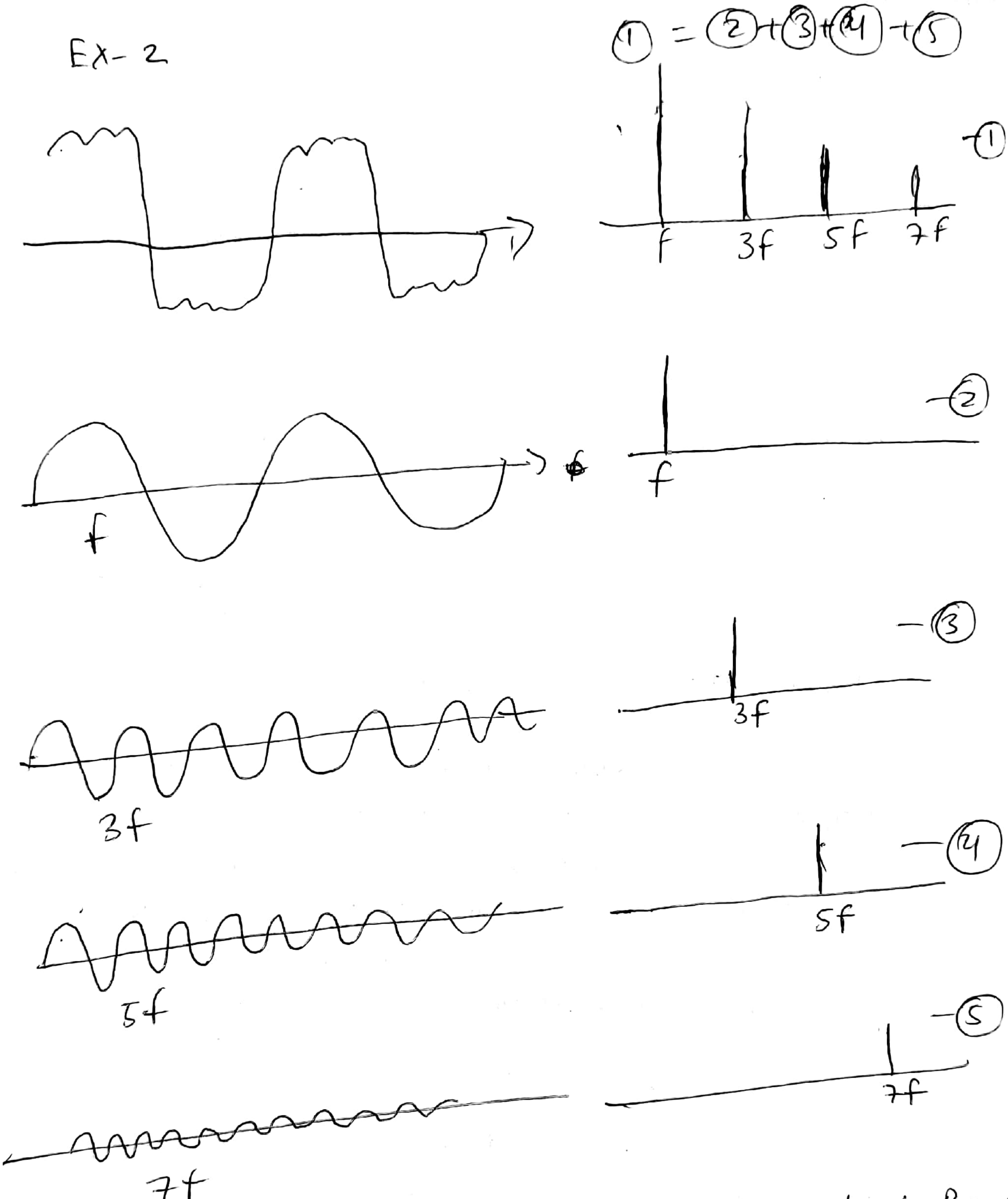
example.



Time Domain   fig: Ex of composit signal.   Freq Domain

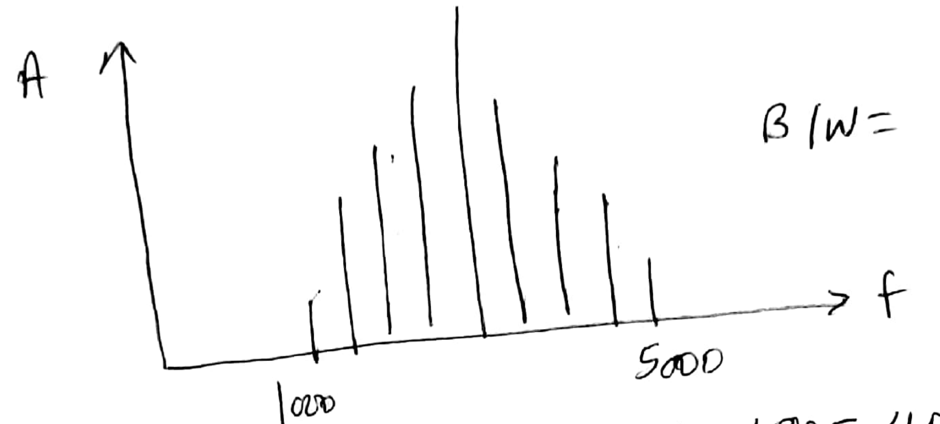


Ex- 2



Frequency spectrum :→ Collection of all the component frequencies . or element within that range : or combination of all sine wave that make up the signal.

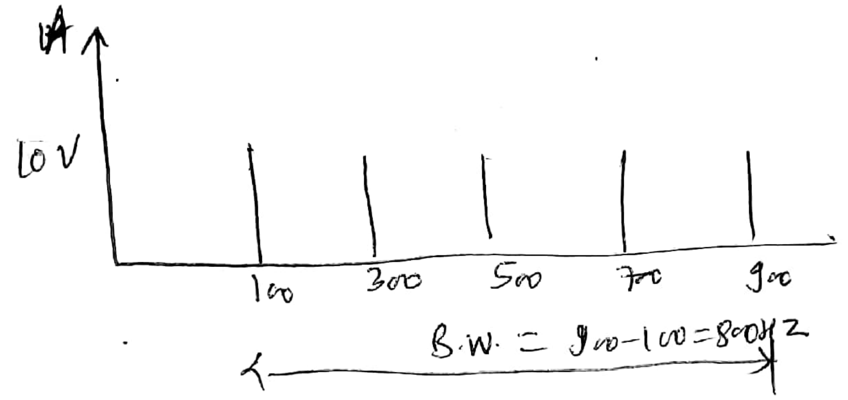
Bandwidth :→ width of the freq. spectrum or range of component frequencies.



$B/W = f_H - f_L$

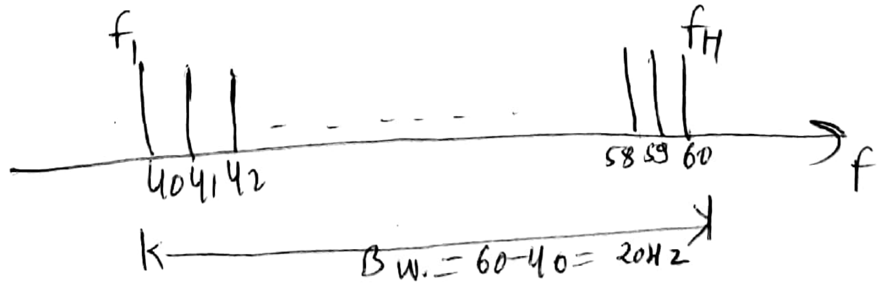
$B.W. = 5000 - 1000 = 4000\,Hz = 4\,KHz$

Ex: If a periodic signal is decomposed into five sine waves freq. 100, 300, 500, 700 and 900 HZ, find B/W. & draw spectrum assume all have $A = 10V$.



Ex: A signal has B.W. = 20 HZ, the highest freq is 60 HZ. what is the lowest freq. ? draw the spectrum if the signal contains all integral frequencies of same Amplitude.

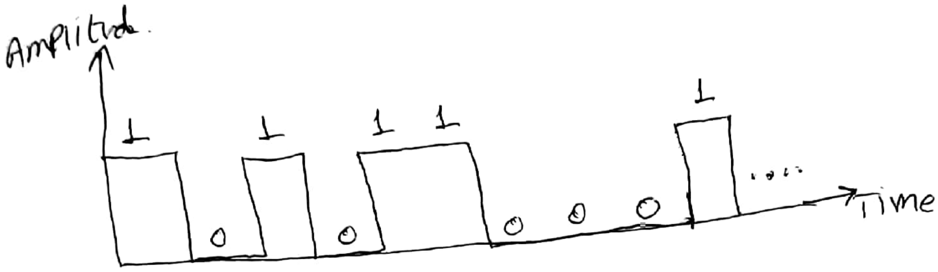
$B = f_h - f_l \Rightarrow 20 = 60 - f_l \Rightarrow f_l = 40\,Hz$



Scanned with CamScanner

Digital Signals: →

encoding of 1 → +ve valate
encoding of 0 → -ve voltage

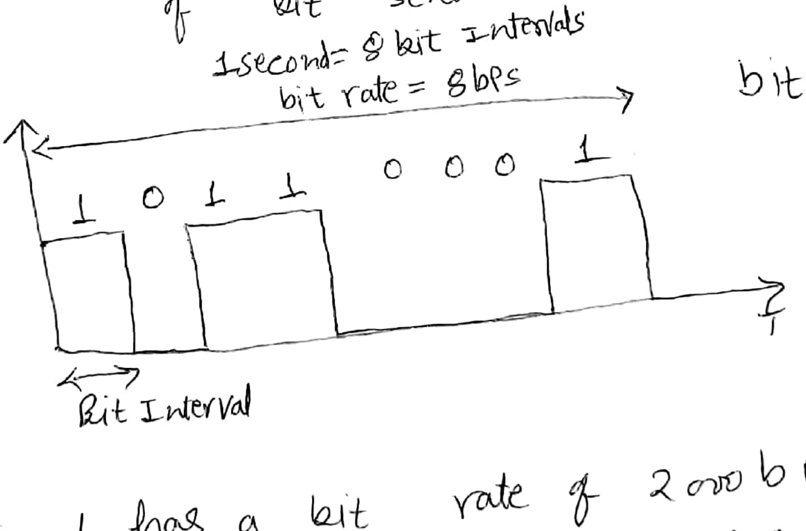


Bit Interval and Bit rate: →

Most Dig. signals are non periodic thus period and freq is not appropriate. Two new terms, bit interval (instead of period) and bit rate (instead of freq) are used to describe digital signals.

Bit Interval: → Time req. to send one single bit.

Bit rate: → No. of bit interval per sec. or No. of bit sent in one second (bPS).



$$\text{bit Interval} = \frac{1}{\text{bit rate}}$$

Ex: A dig signal has a bit rate of 2000 bPS. what is the duration of each bit (bit interval)?

$$\text{bit interval} = \frac{1}{\text{bit rate}} \Rightarrow \frac{1}{2000} = 500 \mu s$$

Ex A dig. signal has a bit interval of 40 μs. find bit rate?

Sol^n: $\frac{1}{40\times10^{-6}}$ = 25 kbps

~~The~~

Fourier Analysis: Any periodic function can be expressed as an infinite sum of sine and cosine function of varying amplitude, freq and phase shift - a Fourier series

$$x(t) = \frac{a_0}{2} + \sum_{i=1}^{\infty}\left[a_i \cos\frac{2\pi i t}{P} + b_i \sin\frac{2\pi i t}{P}\right]$$

a_1, a_2, a_3 -- . b_1, b_2 --- are uniquely determined by this eq. are called Fouri. transform $x(t)$

Bit rate: → Describe information - carrying capacity of a digital channel measured in bit/sec (b/s)

The range of frequencies in a channel is called bandwidth.

a higher - bandwidth channel has a higher bit rat.

bit rate $R = f_n S$

f_s is the freq at which symbols are sent, and the no. of bits per symbol n.

$$\frac{\text{bit}}{\text{sec}} = \frac{\text{bits}}{\text{symbol}} \times \frac{\text{Symbol}}{\text{sec}}$$

As a shorthand for symbols/sec, we write baud

Sampling rate: → The accuracy of any digital reproduction of an analog signal depends on the number of samples taken. Using PAM and PCM, we can reproduce the wave form exactly by taking infinite samples.

According to the Nyquist theorem, to ensure the accurate reproduction of an original analog signal using PAM, the sampling rate must be at least twice the highest freq of the original signal.

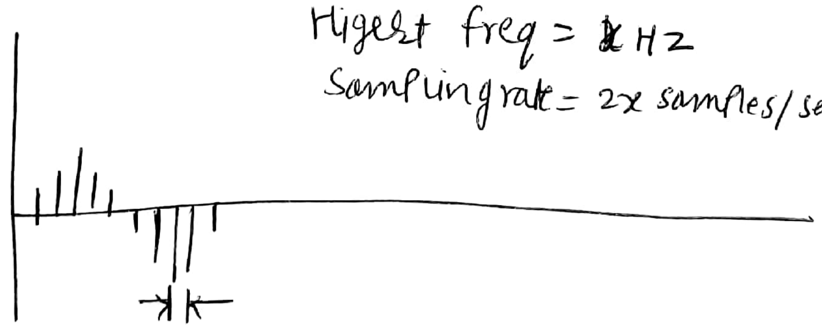
$$f_s = 2 f_m$$

So if want to sample telephone voice with maximum freq 4000Hz, we need a sampling rate of 8000 samples per second.

Means one sample after every $\frac{1}{8000}$ sec.

Higest freq = x Hz

Sampling rate = $2x$ samples/second



Sampling interval $= \frac{1}{2x}$

Signal-to-noise (S/N) ratio or SNR: is measured by the ratio S/N, S is signal power, N is noise power.

A clear signal has a large SNR, and a noisy (distorted) signal has a low SNR.

Since S/N is very large we measure it in dB.

$SNR_{dB} = \log_{10}(S/N)$ bels

unit of measurement is called bel.

$1dB = 0.1$ bel.

If our SNR is 25 db, this is 2.5 bel.

This implies $S/N = 10^{2.5}$ $\therefore$ $S = 10^{2.5} \times N \approx 316N$

Shannon's theorem: → Shannon, inventor of the classical theory of information, refined Nyquist theorem by taking into account the channel's noise.

In a noisy transmission

bit rate (in b/s) $\leq$ bandwidth (in Hz) $\times \log_2(1+\frac{S}{N})$

The quantity $\log_2(1+\frac{S}{N})$ is the max no. of bits that can be transmitted per cycle on this channel.

→ Decreasing $\frac{S}{N}$ of any channel will decrease its information-carrying capacity.

Ex: Telephone carry audio frequencies in the range 300 HZ to 3300 HZ this is a bandwidth of 3000 HZ. A ucoed tel connection has $S/N = 35$ db so.

$$3.5 \text{ bel} = \log_{10}\left(\frac{S}{N}\right) \text{ bel}$$

$$S = 10^{3.5} \times N \approx 3162\,N$$

by theorem.

$$\text{bit rate} < \text{b.W.} \times \log_2\left(1+\frac{S}{N}\right)$$

$$\text{bir rate} < 3000 \times \log_2(1+3162)$$

$$< 3000 \times 11.63 \text{ b/s}$$

$$\approx < 34880 \text{ b/s}$$

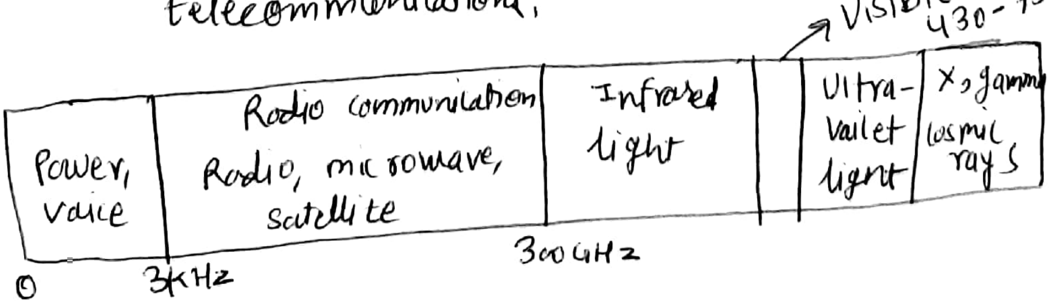
Media :→

Transmission ~~Infairment~~ :→ Signals are transmitted from one device in the form of electromagnetic energy.

E.M. Signal can travel through a vaccum, air, or other transmission media.

Electromagnetic Energy :→ is a combination of electric and magnetic fields vibrating in relation to each other, includes Power, vaice. radio waves, infrared light, visible light, ultravailet light, and x, gamma and cosmic rays. Each of these constitutes a Portion of the Eletromagnetic spectrum.

Nat all Portion of the spectrum are currently usable for telecommunications,



★ Vaice band freq. are generally ~~transmi~~ transmitted as over Metal Cable. such as twisted Pair or coaxial cable.

Radio Frequencies :→ Can travel through air or Space but require specific transmitting and receiving mechanisms.

Visible Light :→ fiber - optic cable.

Transmission Media :→

- Transmission Media
  - Guided
  - Unguided.

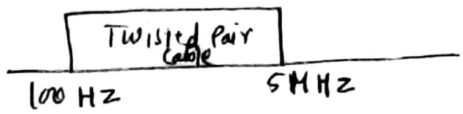
Guided Media :→ Provide a conduit from one device to another. include, twisted - Pair cable, coaxial cable, and fiber optic cable.

- Guided Media
  - Twisted Pair Cable
    Use : copper conductors
    - shielded
    - unshielded
  - Coaxiale Cable
    Use : copper conductors
  - Fibre-optic cable
    uses : Light.

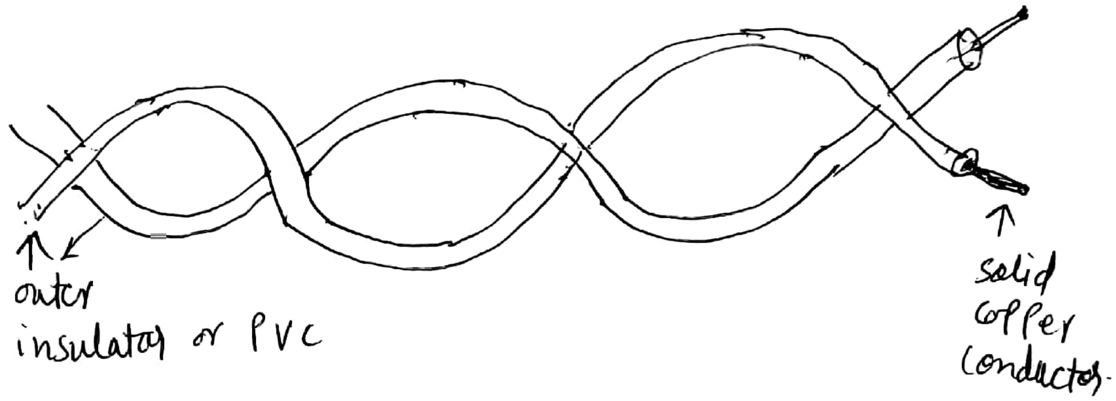
Twisted Pair cable :→ 2 form
- → Unshielded (UTP)
- → shielded (STP)

UTP :→ Most common.
- → use in telephone
- → freq. range is suitable for both data and voice.
- → A Twisted Pair consists of two conductors (usually copper) each with own colored Plastic insulation. Plastic insulation is color banded for Identification.

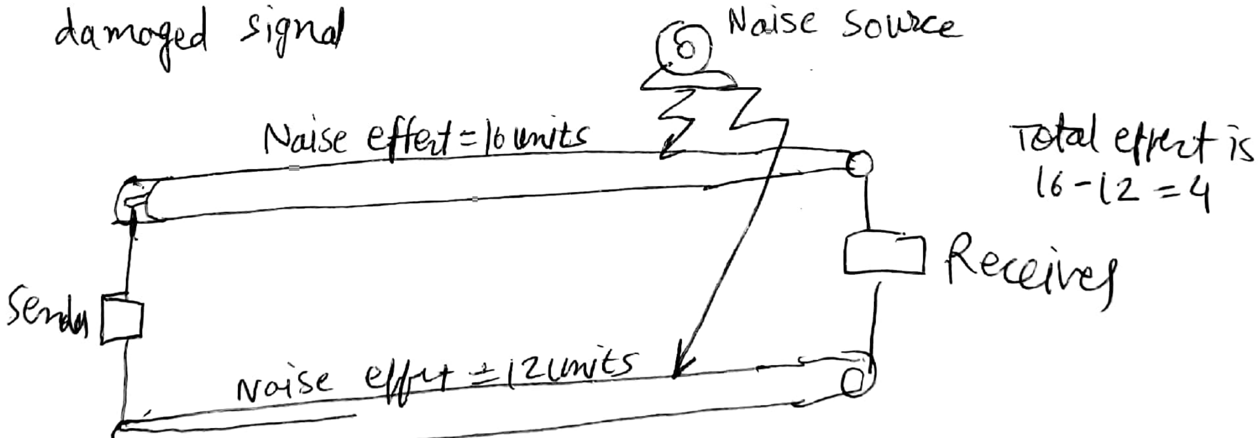
Freq. rang. for twisted pair cable



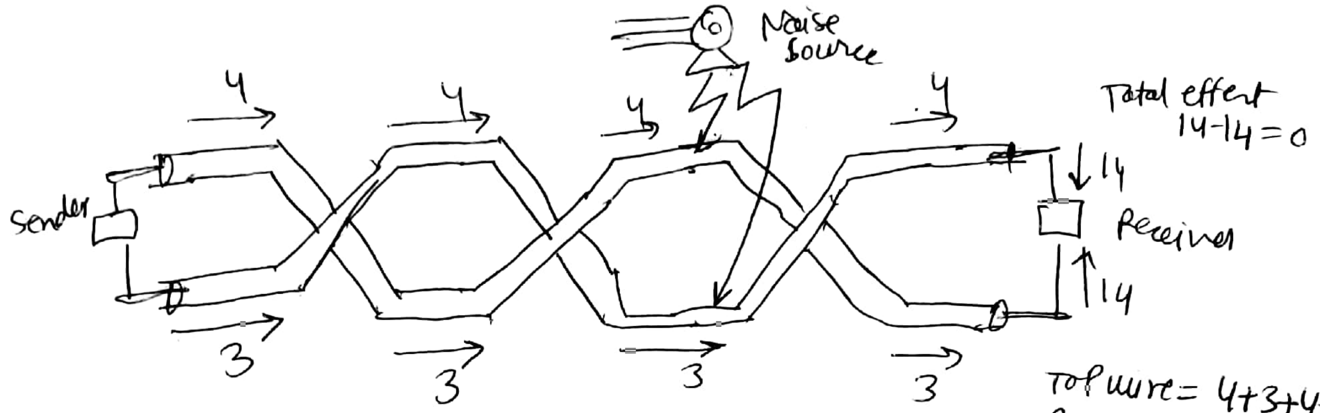
Why Twisted :→ In past, Two Parallel Flat wires were used for communication. electromagnetic interference from devices such as motor can create noise over this wires.



If two ~~gl~~ wires are Parallel, the wire closest to the source of the noise gets more interference and ends up with a higher voltage level than the wire farther away which results in an uneven load and a damaged signal



If However, the two wires are twisted at regular interval. each wire is closer to the noise source for half the time and farther away for the other half. with twisting, therefore, the cumulative effect of the interference is equal on both wires.



Top wire = 4+3+4+3=14
Below wire = ~~4~~3+4+3+4=14

Twisted does not always eliminate the import of noise, but it does significantly reduce it.

Advontages of UTP :→

→ cost and ease of use.

→ cheap, flexible and easy to install

→ Higher graded UTP are used in many LAN technologies, including Ethernet and token ring.

the Kaire cable with five unshielded twisted pair of wire cover in a plastic.

fallowing are the standard grade for UTP.

Lowest→ Category 1 :→ use for telephone, for voice, low speed.

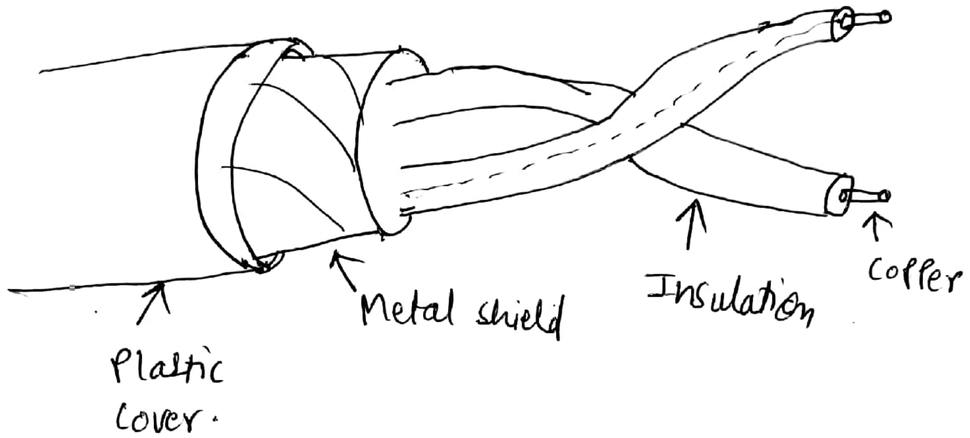
Category 2 :→ voice and data upto 4MbPS

Category 3 :→ Three twists Per foot - upto to 10MbPs. now standard cable for most telephones

Category 4 :→ 3 twist per foot, upto 16 MbPs.

Best→ Category 5 :→ upto 100 MbPS

Shielded Twisted Pair (STP) Cable :→ Has a metal foil or braided-mesh covering that encases each pair of insulated conductors. The metal casing prevents the penetration of EM. noise. It can also eliminate a phenomenon called Cross talk. (one can hear other conversations in background)

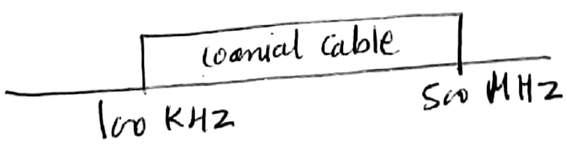


STP has the same quality considerations and uses the same connectors as UTP, but the shield must connected to a ground.

→ Material and manufacturing requirements make STP more expensive than UTP but less susceptible to noise.

Coaxial Cable :→ (or coax)

carries signals of higher Freq ranges than twisted pair cable.

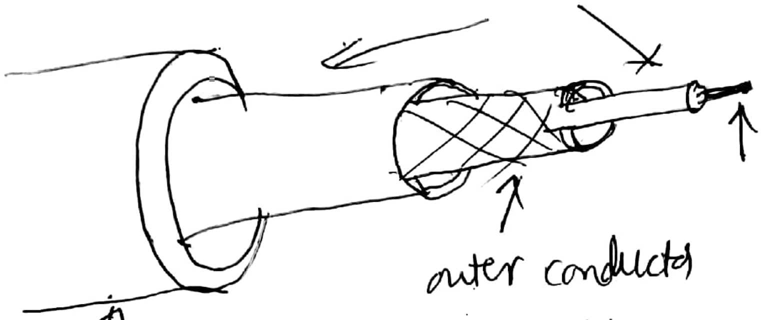


Freq. range of coaxial cable

Instead of having two wires, coax has a central core ~~Constructed~~ conductor of solid or ~~Stand~~ stranded wire enclosed in an insulating sheath which is, in turn enclosed 21 in an outer conductor of metal foil.

→ The outer metallic wrapping serves both as a shield against noise and as the second conductor.

→ The outer conductor is also enclosed in an insulating sheath, and the whole cable is protected by a plastic cover.



Coaxial cable Standards :→ Radio government (RG) number denotes a unique set of physical specifications, including the wire gauge of the inner conductor, the thickness and type of the inner insulator, the construction of the shield, and the size and type of outer casing.

RG-8 :→ used in thick Ethernet
RG-9 :→ used in thick Ethernet
RG-11 :→ used in thick Ethernet
RG-58 :→ used in thin Ethernet
RG-59 :→ used for TV

Coaxial cable Connectors :→ Most popular BNC (Bayonet network connector)

Two others are T-connector and Terminator

used in thin Ethernet

for bus topologies.

Optical fiber :→ Made of glass or Plastic and transmit signal in the form of light

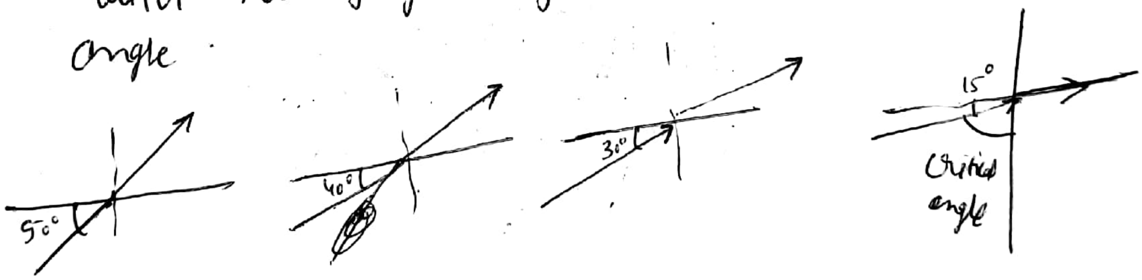
following are several aspect of nature of light.

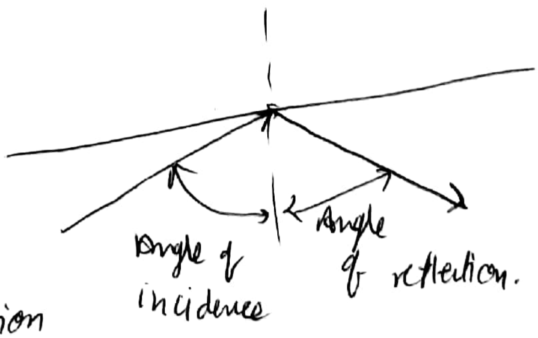
1) Nature of Light :→ form of E.M. energy.. speed of light depends on the density of the medium

2) Refraction :→ If a light travelling through one substance suddenly enters another (more or less dense) substance, its speed changes abruptly, causing the ray to change direction.

3) Critical angle :→ consider a ray of light moving from rarer to denser medium. and we gradually increase the angle of incidence measured from vertical.

At some point in this process, the change in the incident angle results in a refracted angle of 90°, with now lying along the horizontal. The incident angle.





(TIR) Total internal reflection

4) Reflection :→ when the angle of incidence becomes greater than the critical angle, a new Phenomenon occurs called reflection.

Propolagation mode

- Multimode
  - Step-Index
  - Graded Index.
- Single mode

Multimode: → multiple beam from a light source move through the core in different paths. How these beams move within the cable depends on the structure of the core.

Multimode step-Index: → then density of the core remains constant from the centre to the edges. A beam of light moves through this constant density in a straight line ~~until~~ untill it reaches the interface of the core and cladding. At the interface, there is an abrupt change to a lower density that alters the angle of beam's motion.

→ The term step-Index refers to the suddenness of this change.

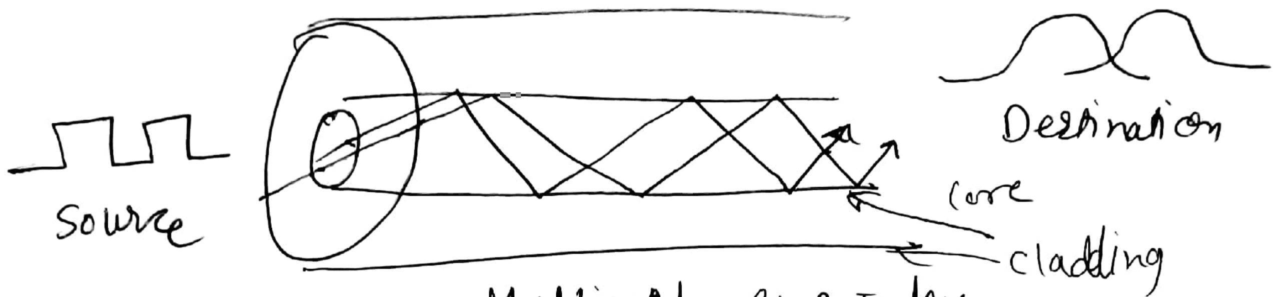
→ signal distorted by Propagation delays. which limits the data rate

Assignment: → ~~why~~ what are the drawbacks of step Index fiber. and how it can be remove.

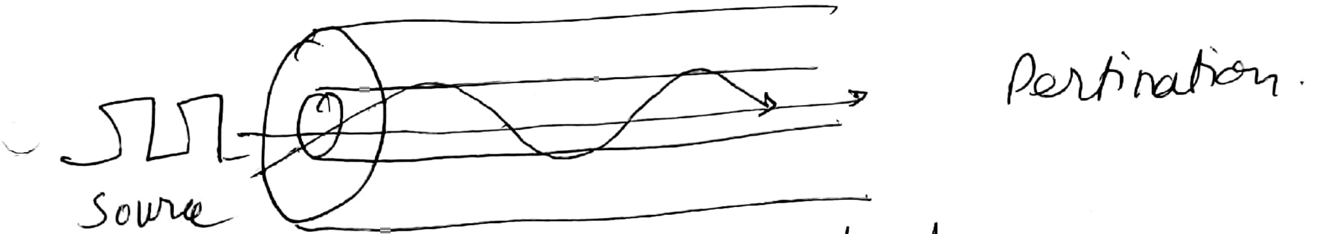
Multimode graded Index: → It decreases the distortion of the signal through the cable.

as Index of refraction is related to density. A graded Index fibre therefore is one with varying densities.

→ Density is higher at centre of ~~core~~ core and decreases gradually to its lowest at the edge.



Multimode step-Index.



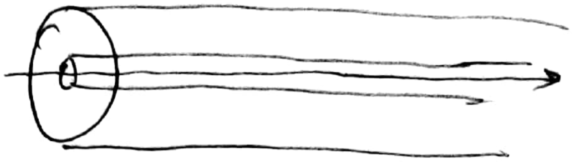
Multimode graded Index.

Single mode: → uses step-Index fibre and a highly focused source of light that limits beams to a small range of angles, all closes to the horizontal.

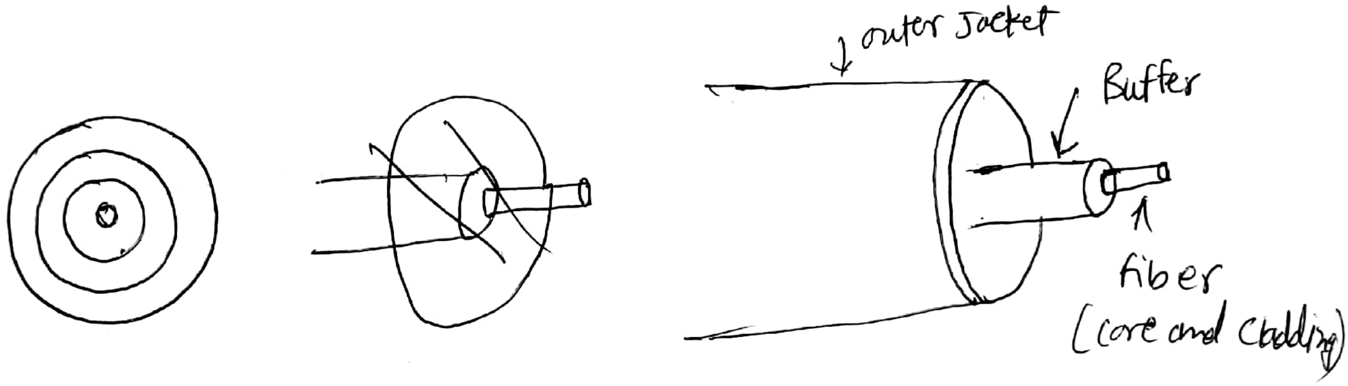
→ manufactured with a much smaller diameter than that of the multimode fibers, with lower density.

→ Decrease in density results in a critical angle that is close enough to 90° to make the propagation of beam almost horizontal.

→ In this propagation of different beam is almost identical and delays are negligible. All the beams arrive at the destination "together" and can be recombined without distortion to the signal.



Fiber construction: → A core is surrounded by cladding forming the fibre. In most case fibre is covered by a buffer layer that protect it from moisture. finally the entire cable is encosed in an outer Jacket.



Light source for optical Fibre :

Unfocused Light — focused light

Sending device :→ Light source (LED, LASER)

Receiving Device :→ Photo sensitive device or Photo diode

Advanges of optical Fiber: →

1) Noise resistance: → uses light. not EM signal noise is not a factor. external light is blocked from outer Jacket.

2) Less signal attenuation: → signal can run over long distance without requiring regeneration.

3) Higher bandwidth :→ Support higher bandwidths (and hence high data rates) than twisted-Pair or Coaxial.

Disadvantages of fibre :→

1) Cost :→ expensive; Because any impurities or imperfection in the core may leads to signal distortion.

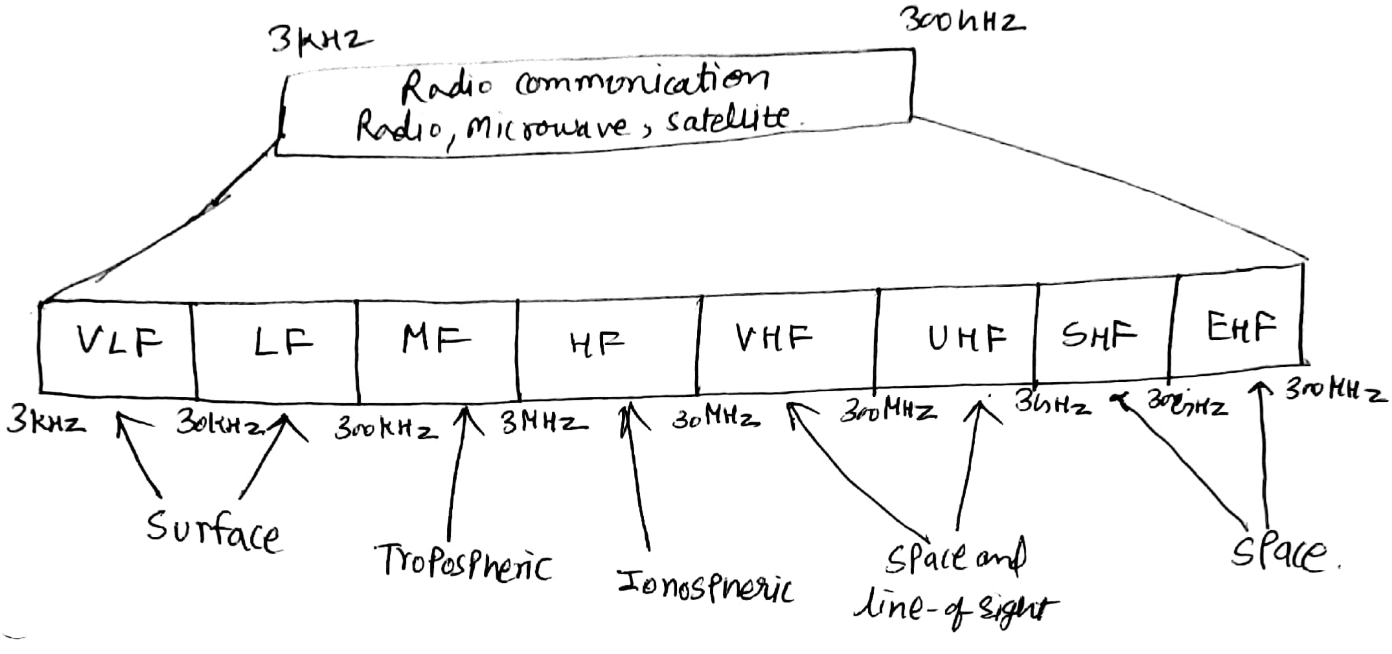
2) Installation/ Maintenance :→ Any roughness or Cracking in the core of an optical cable diffuse light and alters the signals. Can't join like other cables if broken.

3) Fragility :→ More easily broken than wire, making it less useful for many application.

UNGUIDED MEDIA

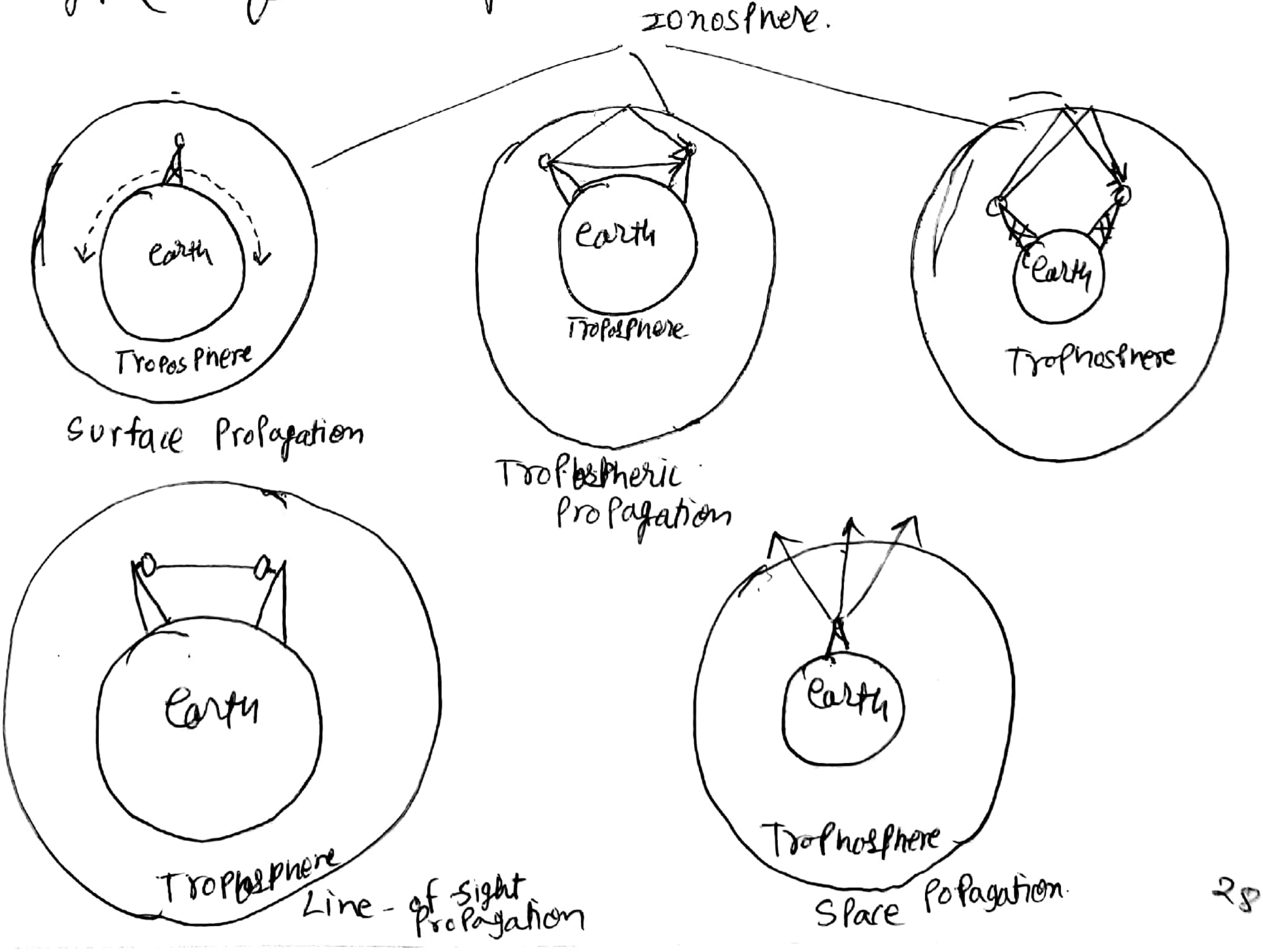
Unguided media, or wireless communication, transport E.M. waves without using conductor. signals are broadcasted through air (or, in a few cases, water)

Radio Freq Allocation :→ section of E.M. Spectrum defined as radio communication is divided into eight ranges. Called bands. Each regulated by government authorities.



Propagation of Radio waves

Types of Propagation :→



Radio tech. considered the earth as surrounded by two layers of atmosphere: troposphere and ionosphere.

Troposphere : → 30 miles from the surface of earth.

(Troposphere includes the high altitudes layer called Stratosphere)

Ionosphere: → Above troposphere but below space. It contains free electrically charged particles.

Types

1) Surface Propagation: → radio waves travels through the lowest portion of the atm. signal from antenna follow the curvature of the planet.
greater the power of signal greater it can travel.
can also take place in sea water.

2) Tropospheric : → Two ways
1) signal can be directed in a straight line from antenna to antenna (line-of sight). Txr and Rxr should be in line of sight
2) It can broadcast at an angle into the upper layers of troposphere where it is reflected back to the earth. greater distance can be covered.

3) Ionosphere → H.F. radio waves radiated upward into the ionosphere where they are reflected back to earth. The density difference b/w trop. and ion.

causes each radio wave to speed up and change direction.
→ allows greater distance with less power o/p.

4) Line of sight: → VHF signals are transmitted in straight lines directly from antenna to antenna.

- Antennas must be directionals, facing each other and tall enough.

→ waves emanate upward and downward as well as forward and can reflect off the surface of the earth or parts of the atmosphere. Reflected waves that arrive at the receiving antenna later than the direct portion of transmission can corrupt the received signal.

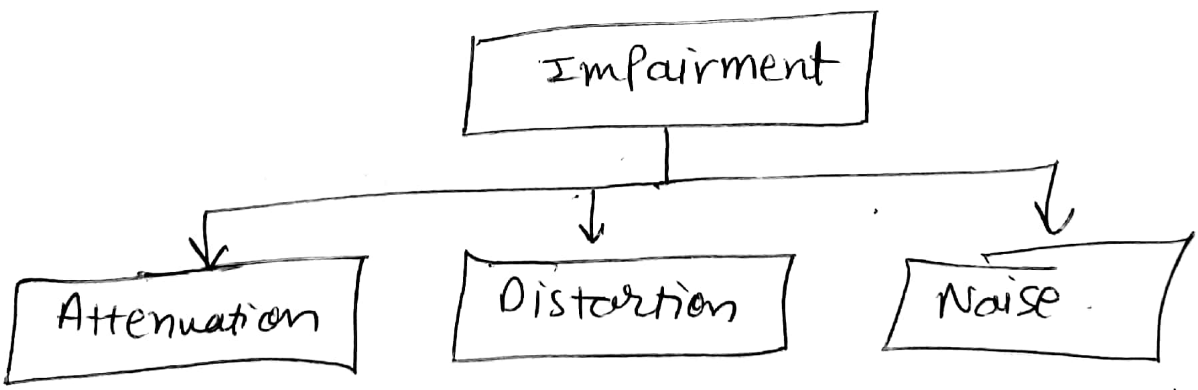
5) Space : → utilizes satellite relays in place of atm. refraction.

→ broadcast signal received by orbiting ~~satellit~~ satellite is rebroadcasted to the intended receiver

Transmission IMPAIRMENT: → transmission media are not perfect. The imperfection causes impairment in the signal.

→ what is sent is not what is received.

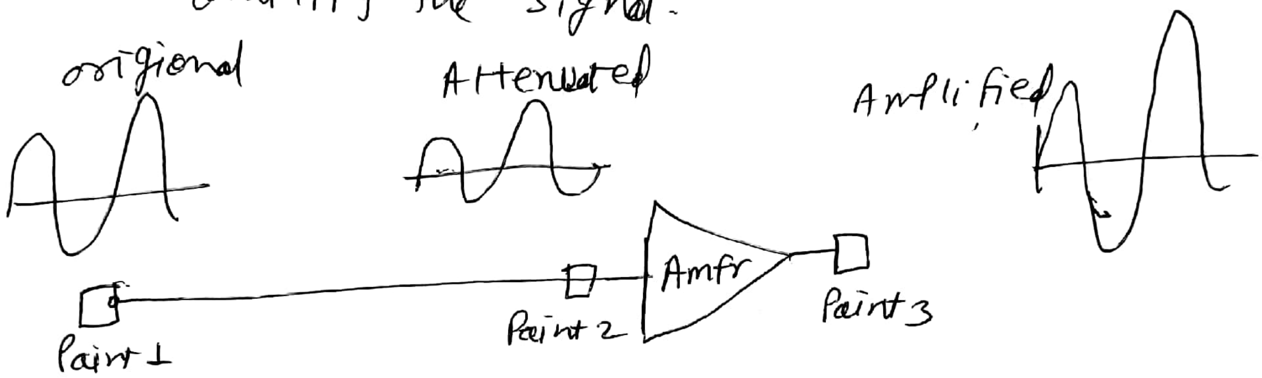
→ 3 Types



Attenuation: → Loss of energy. As signal travels it loses some of its energy so that it can overcome the resistance of the medium. That is why wire gets warm.

→ Some of the electrical energy is converted to heat.

→ to compensate loss amplifiers are used to amplify the signal.



Decibal: → To show that a signal has lost or gained strength, decibal (dB) is used. It measures the relative strengths of two signals at two different paints.

dB → −ve → If signal is attenuated

dB → +ve → If signal is amplified.

$$dB = 10\log\left(\frac{P_2}{P_1}\right)$$

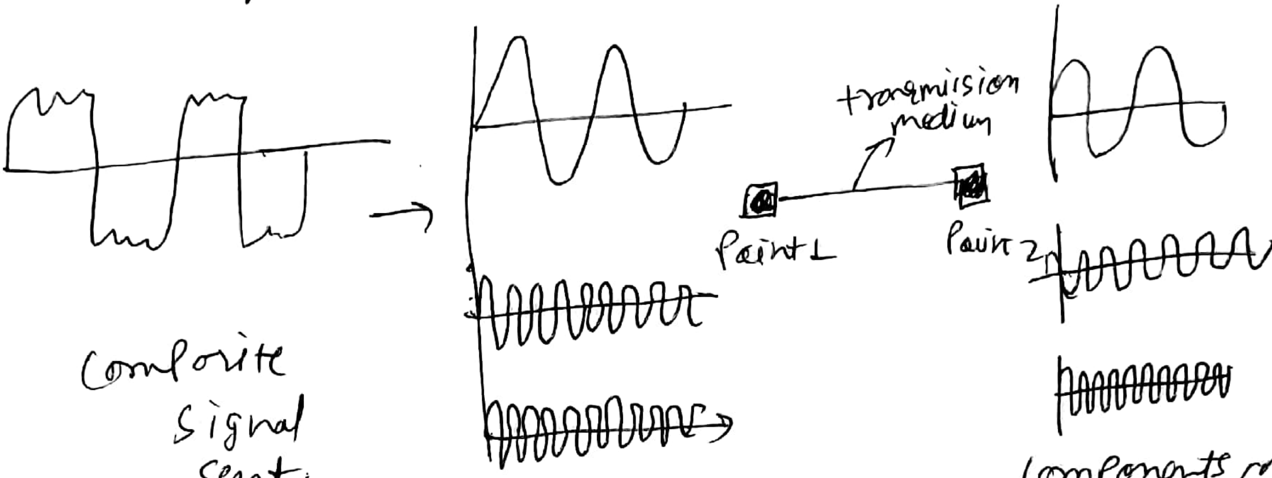
P_1 and P_2 are powers at paint 1 and 2.

−3 dB = loss of 3dB

+3 dB = gain of 3dB.

Distortion: → signal changes its form or shape

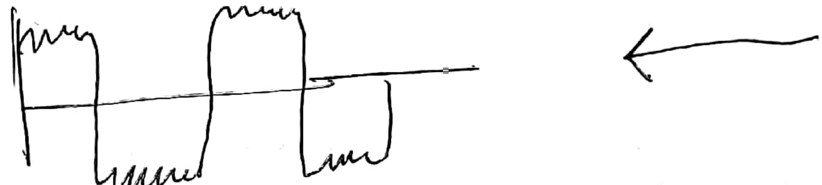
→ occurs in a composite signal, made of different freq.



Composite signal sent.

Components in phase.

Components out of phase.



distorted composite signal received.

Noise: → Any unwanted signal.

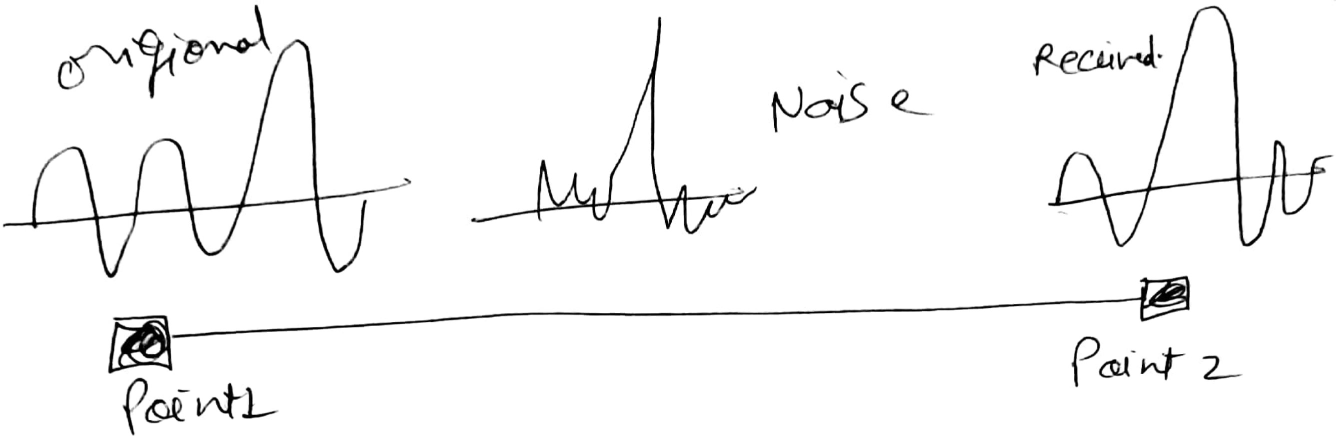
several types. thermal noise, induced noise, crosstalk, and impulse noise may corrupt the signal.

→ Thermal noise: → due to random motion of e^- that creates extra signal.

→ Induced noise: → comes from external source like motor, bus, other appliances.

→ cross talk → Effect of one wire on another.

→ Impulse → is a spike for very short period of time. comes from power line, lightning thundering etc.



origional
Noise
Recived
Point1
Point 2