Page No. ______
Date

5-1-18

Advanced Computer Networks

Communication

Wired   Wireless

Wired Communication

- via voltage, electricity, light energy
- eg: coaxial, twisted pair cables, optical fibres

Wireless Communication

- via electric-magnetic waves
- via $\vec{E}$ and $\vec{H}$
- eg: communication in space, Aerospace, water, woods [Dielectrics)

Types of Materials

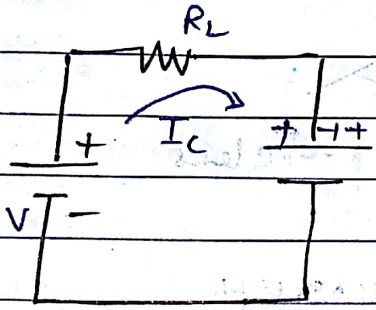
(#) Conductors: property conductivity
(#) Insulators / Dielectrics: property dielectric constant

What is space?
Classical eg: Space is something which never moves.
eg: a boy carrying water in pot, water moves with pot...
water is Non-space.

PHYSICS CONCEPTS

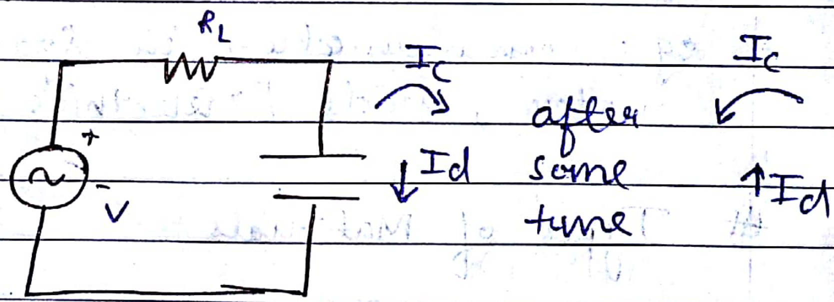
Capacitor in Circuits

⇒ DC Current



In dc circuit current (I_C & I_d) initially flows. After some time it stops because +ve charge is deposited on the capacitor.

⇒ AC Circuit



In AC circuit current initially flows in one direction. After that in opposite direction keeps on repeating this in one direction and then in opp direction and again & again.

I_d — current inside capacitor

Definitions

⇒ Electric Field ($\vec{E}$)

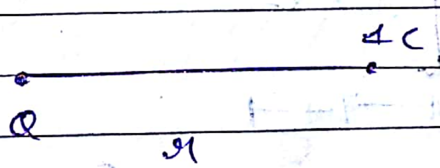
Given Q_1, Q_2 charges at distance r
Force b/w them

$$= \frac{\epsilon Q_1 Q_2}{r^2}$$

di-electric constant

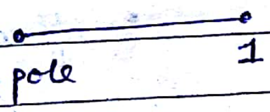
When $Q_2 = 1C$, the force is called electric field

$$\vec{E} = \frac{\epsilon Q \cdot 1}{r^2} = \boxed{\frac{\epsilon Q}{r^2}}$$



⇒ Magnetic Field ($\vec{H}$)

On exact same lines as above.



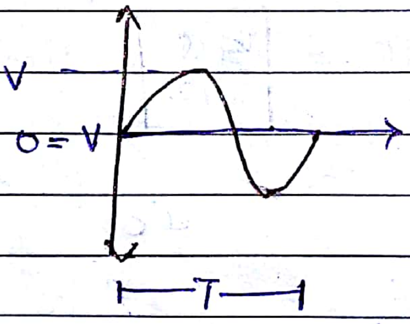
$$\boxed{\vec{H} = \frac{\mu M}{r^2}}$$

17-1-18

Electricity	Magnetic
$\vec{E}$	$\vec{H}$
$\vec{E} = \frac{\epsilon Q}{r^2}$	$\vec{H} = \frac{\mu M}{r^2}$
charges	poles
dielectric constant	magnetic permeability

- Time Varying Voltage

$$V(t) = \cancel{V \sin 2\pi f t} \quad V \sin 2\pi f t$$



- V
  ↳ Peak Voltage
- $f = \text{frequency} = \frac{1}{T}$ (in Hertz)
- Current : $V = IR$
- Amplitude ∝ Loudness
- Power $= kV^2$
- frequency ∝ pitch

$$V(t) = V \sin(2\pi f t + \phi)$$

Time

frequency — phase

- Angle Difference (Time Difference) for Phase

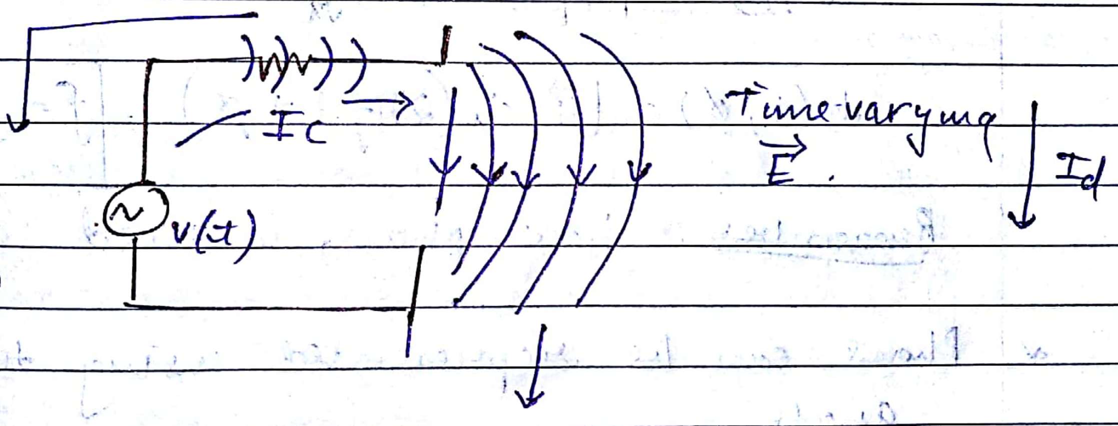
λ: Wavelength

$$\boxed{2\pi \longleftrightarrow T}$$
$$\pi \longleftrightarrow T/2$$
$$\pi/2 \longleftrightarrow T/4$$

Phase : Compared starting time of 2 waves (Informally)
↓
Ek wave dusri wave se kitni peeche hai

#

This $\vec{E}$ won't be radiated much



Corresponding to $\vec{E}$, $\vec{H}$ also exists

Simple Harmonic Motion

There are 2 types of energy transfers

Corpuscular	Wave
[to transfer energy particle needs to physically move]	[No physical movement of particle]
Eg : pebble thrown into water	Eg : Electro magnetic waves

Mass $\propto$ corpuscular n / wave

Simple Harmonic Motion (h(t))

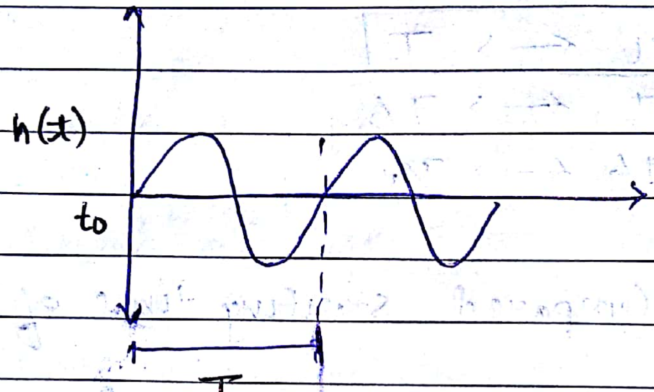


Diagram SHM.1

$$\cancel{h(t,\phi) = |\vec{H}| \sin(2\pi f t}$$

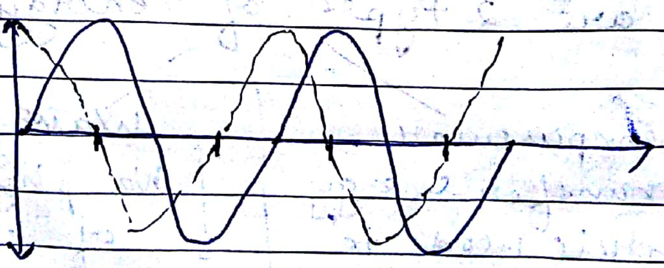
$$h(t,\phi) = |\vec{H}| \sin(2\pi f t + \phi) \quad , \quad \boxed{f = \frac{1}{T}}$$

<u>Remember</u>: how phase is used

* Phase can be represented using time/angle

$$V_1(t) = V \sin 2\pi f t \quad , \quad V_2(t) = V \sin(2\pi f t + \pi/2)$$

diagram of V_1, V_2



2 waves V_1, V_2 at $\pi/2$ or $T/4$
Phase difference

Page No. ______
Date

Now coming back to the SHM of $h(t, \phi)$

Diagram SHM 1

⇒ Up & down motion of particle is simple harmonic motion

$$h(t, 0^+) = A \sin(2\pi f t + 0^+)$$ [For a close particle]

x ——— x ——— x ——— x ——— x ——— x

Wave Equation

Remember 3 things

- t = time instant
- ϕ = phase
- $f = \frac{1}{T}$ frequency ⇒ T = Time period

- Phase and frequency were explained earlier. Now, we will study

- $\boxed{\lambda = \text{Wavelength}}$

Wavelength (λ): Distance b/w 2 consecutive points which are in the same phase

Page No.
Date

Thus phase can also be expressed in terms of distance x.

Angle Difference   Distance

$2\pi \longleftrightarrow \lambda$

Thus wave equation in terms of x

$$\boxed{h(t,x) = H \sin\left(2\pi f t + \frac{2\pi}{\lambda} x\right)}$$

Point Antenna : generates spherical wave
Cylindrical Antenna : generates cylindrical wave
Wave Fonts (or Fronts) : All pt's in the same phase are joined forming a circle

Plane wave : Suppose x is large $\Rightarrow$ cylinder wave appears to be plane.

$$\boxed{v = f\lambda} \Leftrightarrow f \propto \frac{1}{\lambda}$$

19-1-18

Date

→ In this class Sir discussed various frequency spectrums.
Since the data given in the class wasn't reliable only some of it is Mentioned.
All the frequency bands to be studied are specified with ??

Speed of Light in space $= 3 \times 10^8$ m/s
$=$ (??) miles/hr

* In electric medium (or any medium) velocity is less

Frequency generated by Larynx = 300 — 4K Hz (??)

Telephonic Voice Bandwidth = ?? 0 — 4KHz
Television video " = ?? 5MHz

Our ears can listen upto 20 KHz from 300Hz

Music : 0 — 20 KHz (??)

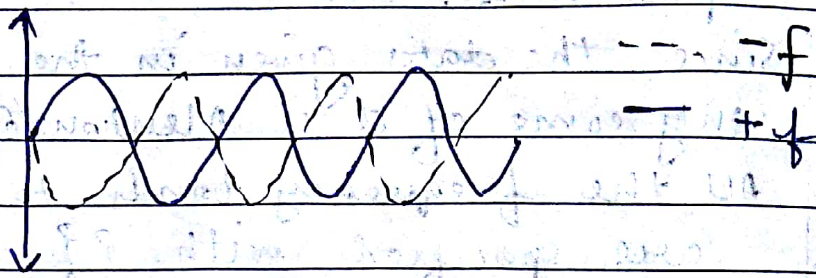
#

$$\boxed{\text{Bandwidth} = \text{Highest frequency} - \text{Lowest frequency}}$$

Audio frequency converted to Electrical frequency remains same

Absolute Space frequency $= 0 \to \infty$
Logically $= -\infty — \infty$

What is -ve frequency?



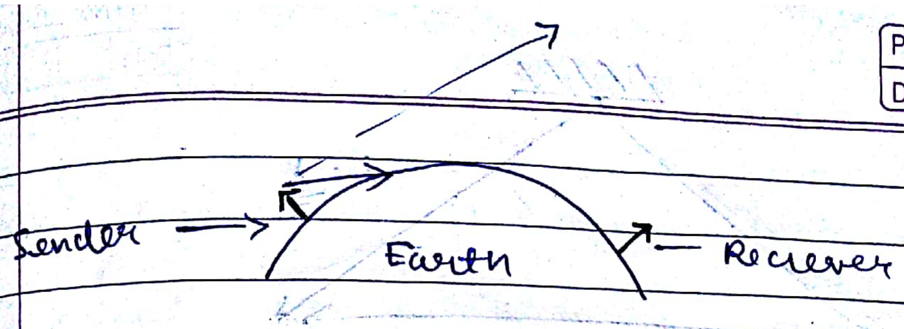
CONCEPTS TO BE STUDIED from TANNENBAUM (or Frouzan acc to me)

- Gaurd Band
- Ladder Frequency
- Conic Beam
- Microwave Communication
- Line of sight Communication
- Following Frequencies
  * VLF, HF, VHF, SHF
  * Microwave
  * Wifi
  * Radio
  * Satellite
  * Twisted Pair Cables (S, US, Cat's)
  * Coaxial
  * Optical

Properties of Micro wave Communication

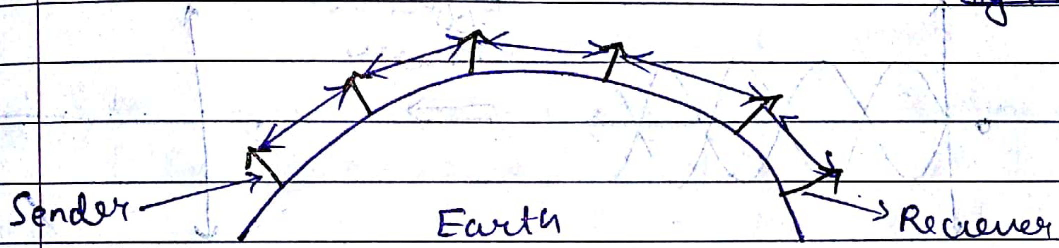
(1) Bandwidth / Frequency : 2.5 GHz and above [CROSS CHECK]

(2) Microwaves travel in straight line
This is also called ...



Problem : A beam too low won't reach reciever
collide with ground
A beam too high will go into space.

Solution : Multiple antennas (30 m - 300 m ~~high~~ Cross Check)



(3) Microwave (M.W) is effected by environment and atmospheric conditions
Eg: rain, fog, vegetation, etc.

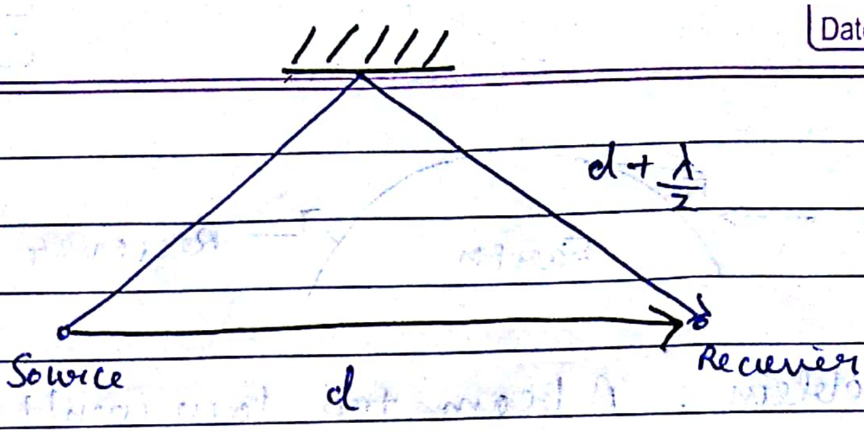
(4) Multiple - Multiple Reflections (STUDY briefly)
This used to create Ghost images earlier.

(5) Multipath Fading (Very Important)

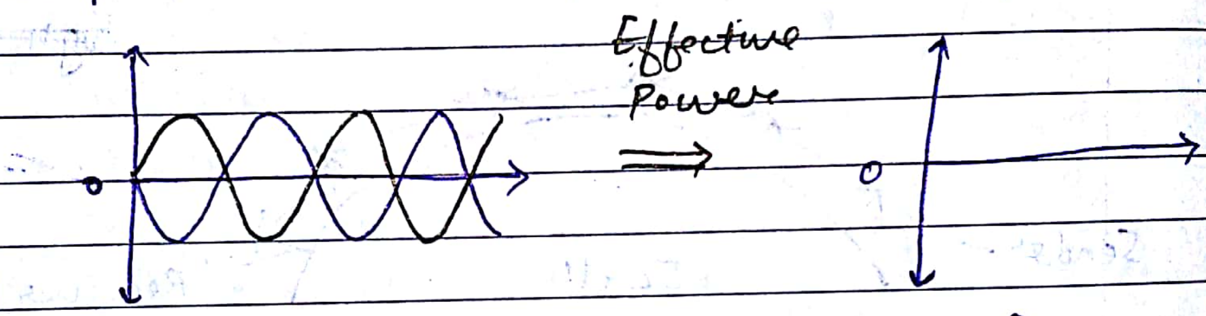
Eg: When we walk in a room while talking on a phone, we notice signal strength keeps varying on short distances.
This is due to multi-path fading.

Cause : Interference of waves (acc. to me)

The following content will be explained

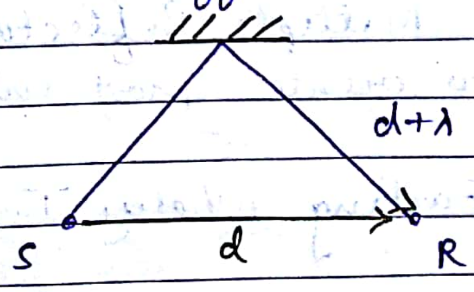


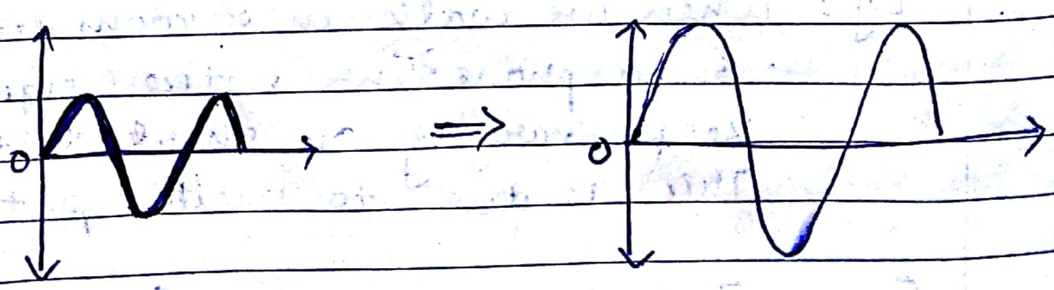
Case 1: The reflected wave arriving at receiver after travelling $d+\frac{\lambda}{2}$ distance
Thus 2 waves at reciever will be different phase



→ $d+\frac{\lambda}{2}$ wave ; → d wave

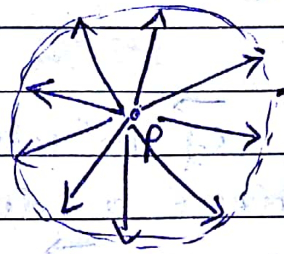
Case 2: The path difference is λ





24-1-18

- Microwave strength varies with distance
- Let P be the power generated at center



$$P/A = P/4\pi r^2 \propto \frac{P}{r^2}$$

- More you move away less will the power [In free space]

MULTIPATH FADING

- Power will vary from 0 to twice

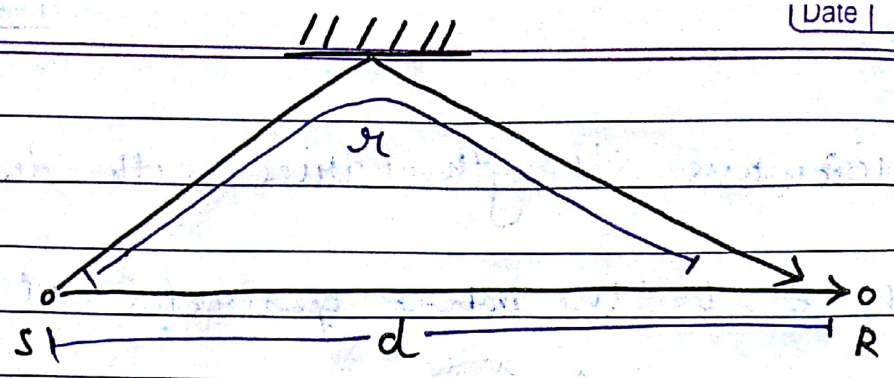
Given sender • ———— • Reciever

- If 2 waves arrive from S to R in same phase, power is doubled
- If 2 waves arrive from S " – " in opposite phase, power is 0 (they will cancel each other)

Imp
- Here we will express phase in terms of path difference (i.e distance x).

Remember

$$\boxed{2\pi \longleftrightarrow T \longleftrightarrow \lambda}$$



- Consider a wave $\vec{e_d}$ which goes from S to R and covers a distance 'd'.
- Consider another wave $\vec{e_r}$ which goes ~~and~~ from S ~~the~~ and is reflected to R after covering a total distance 'r'.

Wave equations

$$\vec{e_d} = E \sin\left(2\pi f t + \frac{2\pi}{\lambda} d\right)$$

$$\vec{e_r} = E \sin\left(2\pi f t + \frac{2\pi}{\lambda} r\right)$$

At the reciever R, the resultant wave $\vec{e}$

$$\vec{e_e} = \vec{e_d} + \vec{e_r}$$

Path difference b/w the 2 waves at R
$= d - r$.

Now ~~cal~~ we analyze some values of 'r' and calculate the effective signal at R.

Case 1: $r = \lambda + d$

Path difference $= \lambda$

Page No. ______
Date

$\Rightarrow$ Angle difference $= 2\pi$

Algebraic Explanation

$$\vec{e_e} = \vec{e_d} + \vec{e_r}$$

$$= E\sin\left(2\pi ft + \frac{2\pi}{\lambda}d\right) + E\sin\left(2\pi ft + \frac{2\pi}{\lambda}(\lambda+d)\right)$$

$$= E\sin\left(2\pi ft + \frac{2\pi}{\lambda}d\right) + E\sin\left(2\pi ft + 2\pi + \frac{2\pi}{\lambda}d\right)$$

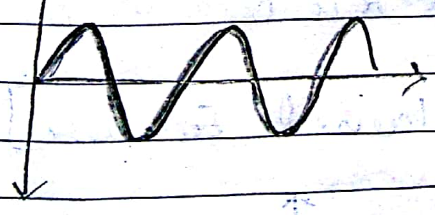
[$\because$ We know $\sin\theta = \sin(\theta + 2\pi)$]

$$= E\sin\left(2\pi ft + \frac{2\pi}{\lambda}d\right) + E\left(\sin 2\pi ft + \frac{2\pi}{\lambda}d\right)$$

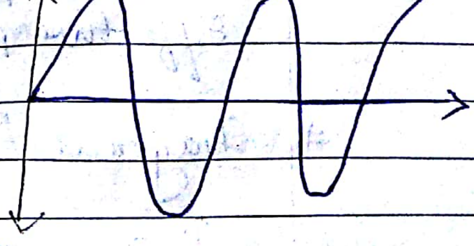
$$= \boxed{2E\sin\left(2\pi ft + \frac{2\pi}{\lambda}d\right)}$$

$\therefore$ When path difference $= \lambda$. Effective power at R is doubled.

Diagram [was explained earlier]



$\Rightarrow$



$\longrightarrow$ d

$\longrightarrow$ d + λ

Amplitude doubles in effective wave

Page No.
Date

Case 2 : $r = d + \frac{n\lambda}{2}$ $n = 1, 3, 5 \ldots$

Path difference $= \frac{n\lambda}{2}$

$\Rightarrow$ Angle difference $= n\pi$

Algebraic Explanation

$\vec{e_e} = \vec{e_r} + \vec{e_d}$

$= E \sin\left(2\pi f t + \frac{d2\pi}{\lambda}\right) + E \sin\left(2\pi f t + \frac{2\pi}{\lambda}\left(\frac{n\lambda}{2} + d\right)\right)$

$= E \sin(\underbrace{2\pi f t + \frac{2d\pi}{\lambda}}_{\theta}) + E \sin(\underbrace{2\pi f t + \frac{2\pi d}{\lambda}}_{\theta} + n\pi)$

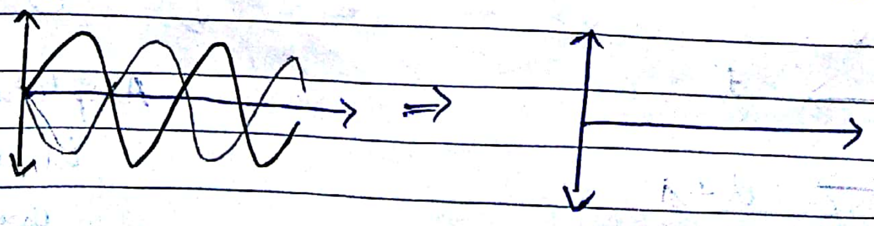
[We know $\sin(\theta + n\pi) = -\sin\theta$ if n is odd integer]

$= E \sin\left(2\pi f t + \frac{2\pi d}{\lambda}\right) - E \sin\left(2\pi f t + \frac{2\pi}{\lambda} d\right)$

$= 0$

$\therefore$ when path difference $= \frac{n\lambda}{2}$ [n: odd integer]
Effective power at R is 0

Diagram [was explained Earlier]



effective power nullified.

Page No.
Date

How to go about solving such questions in exams.

For eg: we are given 3 waves arriving at the Reciever with the original wave with path differences as λ, $\frac{\lambda}{2}$ and $\frac{\lambda}{4}$ respectively

Now, λ and original $\Rightarrow$ Energy doubled
$\frac{\lambda}{2}$ and original $\Rightarrow$ Energy becoms 0

Thus the combined effect of waves with λ & $\frac{\lambda}{2}$ path differences is NULL.

Hence all we have at R are 2 waves
1) Original (Assuming it covers distance d)
2) A wave with path difference $\frac{\lambda}{4}$

$$\vec{e}_e = E\sin\left(2\pi ft + \frac{2\pi}{\lambda}d\right) + E\sin\left(2\pi ft + \frac{2\pi}{\lambda}\left(d+\frac{\lambda}{4}\right)\right)$$

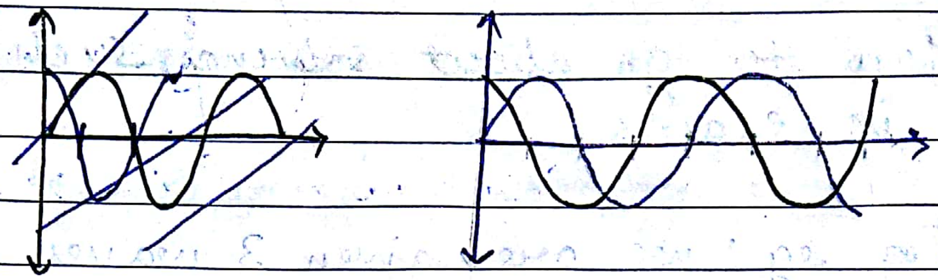
$$= E\sin\left(2\pi ft + \frac{2\pi}{\lambda}d\right) + E\sin\left(2\pi ft + \frac{2\pi d}{\lambda} + \frac{\pi}{2}\right)$$

[We know $\sin\left(\theta + \frac{\pi}{2}\right) = \cos\theta$]

$$= E\sin\left(2\pi ft + \frac{2\pi}{\lambda}d\right) + E\cos\left(2\pi ft + \frac{2\pi d}{\lambda}\right)$$

[Solve further] ....

Diagram



Effectives waves at R

∴ Some Fading will be there.

Sir discussed another example in class where we have 4 additional waves to the source wave : $\lambda, \frac{\lambda}{2}, \frac{\lambda}{6}, \frac{\lambda}{8}$

Thus in the case

$$\vec{e_0} = E\sin\left(2\pi ft + \frac{2\pi}{\lambda}d\right) + E\sin\left(2\pi ft + \frac{2\pi}{\lambda}\left(\frac{\lambda}{6}+d\right)\right)$$
$$+ E\sin\left(2\pi ft + \frac{2\pi}{\lambda}\left(d + \frac{\lambda}{8}\right)\right)$$

This wasn't discussed further in detail...

DIFFERENT TYPES OF COMMUNICATION

There are 2 forms of communication, but before describing them, we will define what is a signal and discuss its differences with other terms

What is Signal? ⇒ Signal is an encoded form of message we are going to send.

- Knowledge.
It is highly structured . D...

b/w fields is known. Space complexity : ?? (finite)

- Information : Data which is assigned meaning.
  We have assigned some meaning
  Eg : 1010 (Raw) , 1010 ⟹ assigned as Roll No.

- Data : Raw facts and figures
  We haven't assigned meaning
  Eg : 1010 (Raw Form)

- Signal : When we wish to transmit data/ Knowledge / info , we encode it and place it on a medium. This is signal.

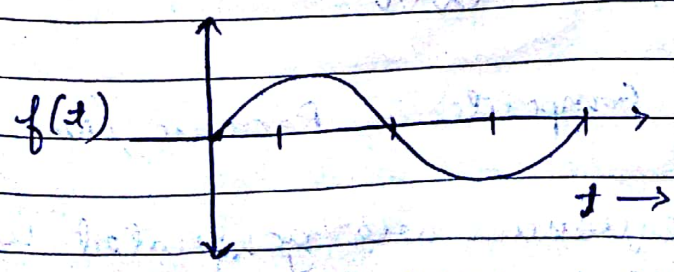
* Note :— A constant signal ⟹ No info. is transmitted

- Communication is of 2 types (i) ANALOG
  (ii) DIGITAL

ANALOG COMMUNICATION

- Signal is analog : eg : current, voltage ; light ..
- Medium : UTP, co-axial , optical fibre , space.

- An analog signal is continous. It should vary with time. More the variation, more is the information



Date

- Condition of continuity:

$f(t - \epsilon) = f(t) = f(t + \epsilon)$, ϵ : a very small quantity

- Analog signal can be classified in 2 ways

1#

Periodic	Non Periodic
$f(t) = f(t+T)$	$f(t) \neq f(t+T)$

Note ⇒ T : Time period

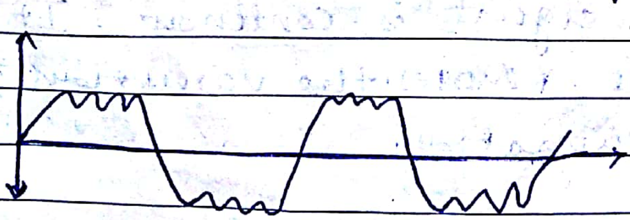
Period signal repeat themselves after a constant amount of time.

2#

Pure	Composite

- Pure Signal:
  A signal has only 1 frequency.
  Eg: sine wave / cos wave
  $\sin 2\pi f t$ (Periodic + Pure)

- Composite Signal:
  Multiple frequencies in a signal
  Eg: $\sin 2\pi f_1 t + \sin 2\pi f_2 t$



Eg: using diagram

Note : Voice : Composite + Periodic / Non-Periodic

NOTE : Frequencies are generated using OSCILLATORS & FREQUENCY GENERATORS

Page No.
Date

MODULATION

Q Why do we need modulation?

- Consider the following example:

Suppose we wish to transmit 2 voice signals S_1, S_2 (Stations)

$S_1 \rightarrow 0 - 20KHz$ } Both have same
$S_2 \rightarrow 0 - 20KHz$ } frequency range
⇒ Become JUNK.

- 2 Analog frequencies within the same range intermix and can't be separated.
Solution to this problem is MODULATION

Notion of Modulation

- We don't transmit our signal within 0-20KHz at all.
∵ Lower frequencies have low Power
- Instead we make use of a very high frequency known as "carrier frequency" or "ladder frequency" [can be more than 1]

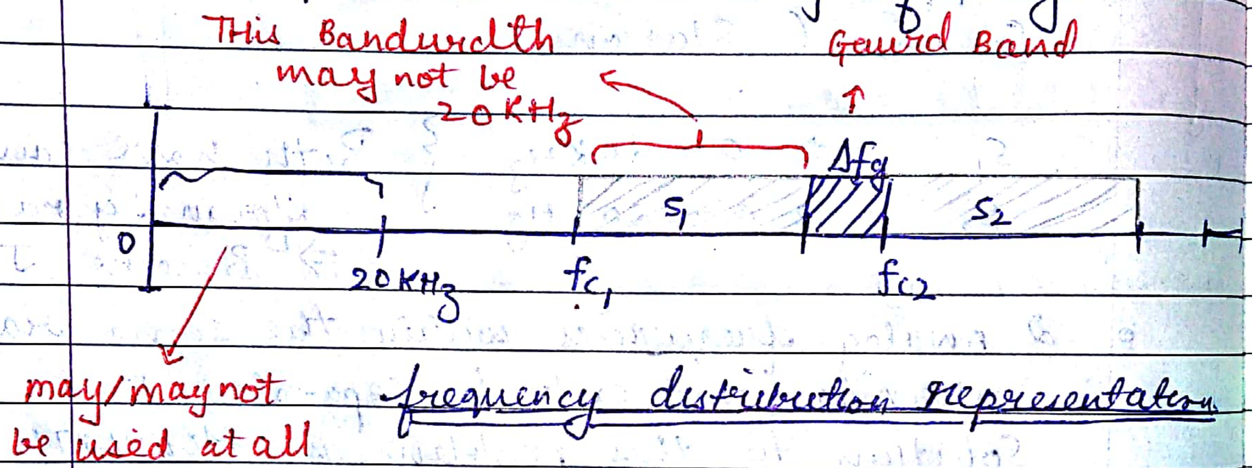
- Our original ~~frequency~~ signal is superimposed over carrier frequency at sender's end.
This is the informal def.^n of MODULATION.

- At receiver's end the original signal is recieved from the modulated signal. This is DEMODULATION.

Page No.
Date

- For the above example we make use of 2 carrier frequencies f_{c_1}, f_{c_2} for s_1 and s_2 respectively

- GAURD BAND: A gaurd band is used to prevent intermixing of 2 signals



frequency distribution representation

V.Imp ⇒ The bandwidth for send s_1 may/may not be 20 KHz. It depends On the type of modulation technique used

3 TYPES OF MODULATION

1) ~~ANALOG~~ AMPLITUDE MODULATION (AM)
2) FREQUENCY MODULATION (FM)
3) PHASE MODULATION (PM)

Note :
- FM is better than AM in terms of quality
- FM is more expensive than AM in terms of bandwidth
- PM is not used practically.

AMPLITUDE MODULATION

- In amplitude modulation, the amplitude of the <u>carrier</u> waves varies proportionally to original signal. Frequency and phase remain constant.

technically incorrect term

Original Signal : $s(t) = S\sin[2\pi f_s t + \phi_s]$

Carrier Signal : $c(t) =$ ~~C sin (2π~~ $C\sin(2\pi f_c t + \phi_c)$

$$\boxed{f_c >>> f_s}$$

AM modulated signal

$$c(t)_{ma} = [C + K_a s(t)]\sin(2\pi f_c t)$$

Note ⇒ For simplification, we assume
$\phi_s = 0$; $\phi_c = 0$
∵ Phase doesn't effect the B/W in modulation

K_a : Constant of AM

Time Domain Representation

$$c(t)_{ma} = [C + K_a s(t)]\sin(2\pi f_c t)$$

$$= [C + K_a S\sin(2\pi f_s t)]\sin(2\pi f_c t)$$

$$= \underbrace{C\sin(2\pi f_c t)} + C K_a \sin 2\pi f_s t \sin 2\pi f_c t$$

Note ⇒ Carrier Remains Same after Modulation

Date

$$= C\sin 2\pi f_s t + \frac{2}{2} K_a S \underbrace{\sin(2\pi f_s t)}_{A} \underbrace{\sin(2\pi f_c t)}_{B}$$

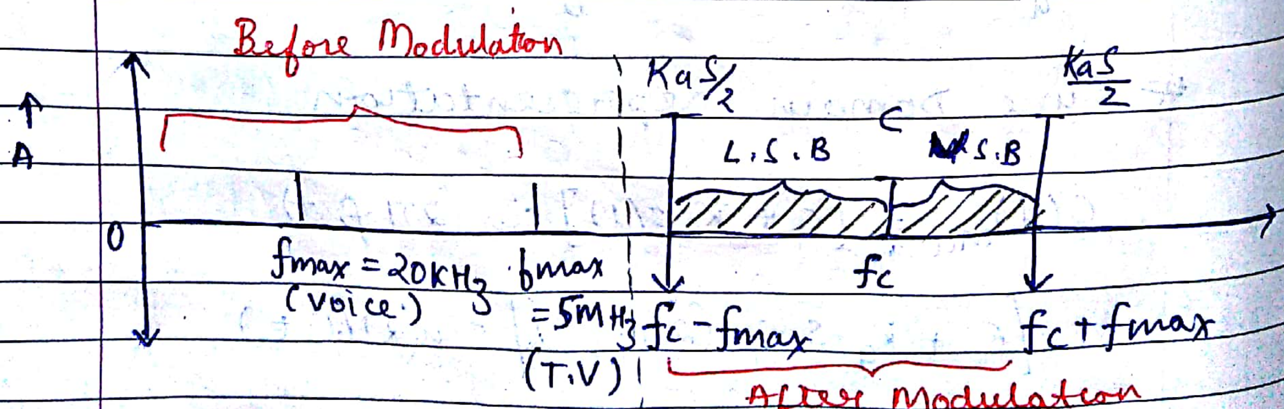
[We Know,

$$2\sin A \sin B = \cos(A-B) - \cos(A+B)$$

$$= \boxed{C\sin 2\pi f_c t + \frac{K_a S}{2}\left\{\cos 2\pi (f_c - f_s)t - \cos 2\pi (f_c + f_s)t\right\}}$$

- We call
  frequency of signal $= f_s = f_{max}$
- Thus final modulated signal has 3 frequences
  $= f_c, f_c - f_s, f_c + f_s$
  $= \boxed{f_c, f_c + f_{max}, f_c - f_{max}}$

Frequency Domain Representation



~~L.S.B = M.S.B~~

f_{max} : Voice $= 20 KHz$
TV $= 5 MHz$

~~L.S.B = Left Side Band~~

U.S B = Upper Side Band

L.S B = Lower Side Band

Original Bandwidth (B/W)

$$BW_c = f_{max} = f_c$$

Bandwidth of Modulated Signal

$$BW_m = f_c + f_{max} - [f_c - f_{max}] = 2f_{max}$$

NOTE : L.S.B = U.S B = f_{max}

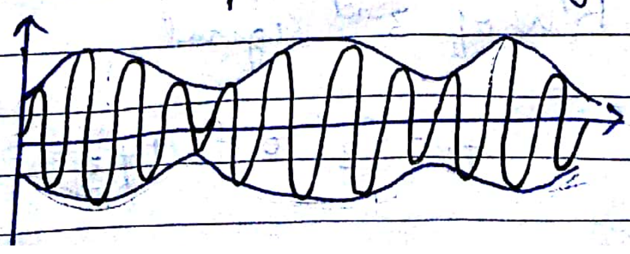
* Now, even if we send 1 band, the quality of Amplitude modulated signal is not effected much

Effective Bandwidth (Generally USB)

$$\boxed{BW_{S(e)} = f_s = f_{max}}$$

Wave Representation

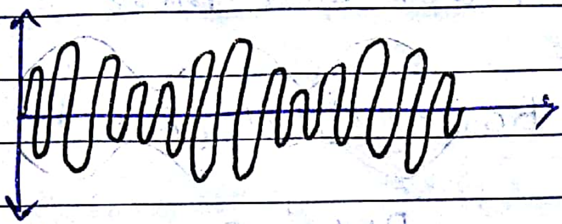
- There are many sine waves
- It is a composite analog signal



Date

Note : lines in blue are for assistance only.

Wave looks like (ACTUALLY



Multiple frequencies [CROSS-CHECK]

VImp

- In AM the required bandwidth depends only on the frequency (Maximum) of the original signal i.e 1 frequency only [If f_c is Same]

Let ~~one us~~ us say we wish to send 3 signals f_1, f_2, f_3 frequencies such that using carrier frequency f_c

$$f_3 > f_2 > f_1$$

Then B/W of 1 signal

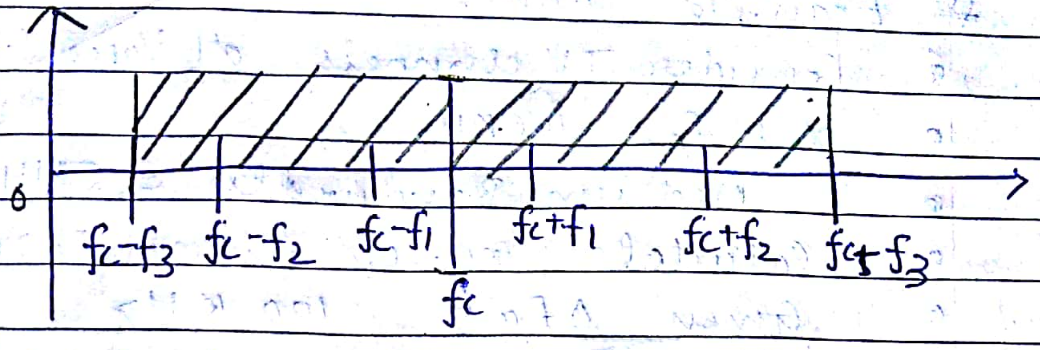
$$= f_c - f_1 \text{ to } f_c + f_1$$

B/W of 2nd signal

$$= f_c - f_2 \text{ to } f_c + f_2$$

B/W of 3rd signal

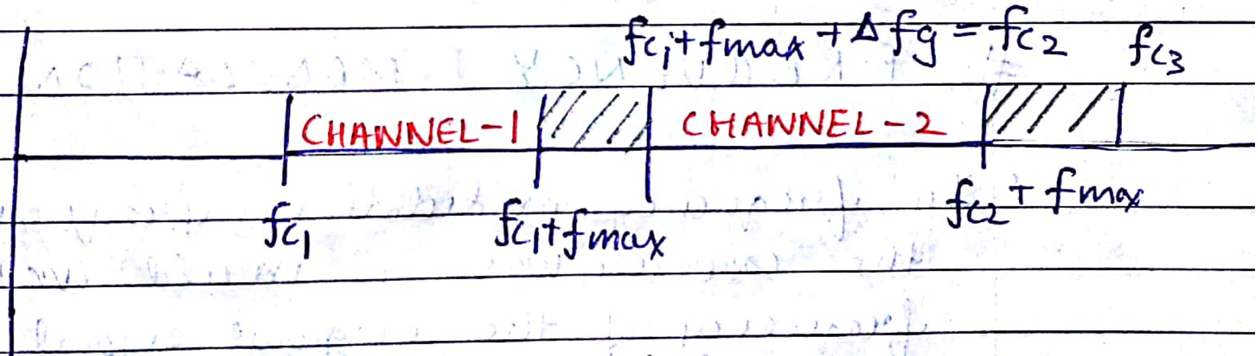
$$= f_c - f_3 \text{ to } f_c + f_3$$



frequency domain representation

FREQUENCY DIVISION MULTIPLEXING IN (AM)
(F.D.M in A.M.)

- We create multiple channels using different carrier frequencies
- We use V.S.B only.



$$f_{c_2} = f_{c_1} + f_{max} + \Delta f_g$$

$$f_{c_3} = f_{c_2} + f_{max} + \Delta f_g \; \ldots \ldots$$

For n channels

$$\boxed{\text{Total Bandwidth Used } (f_{cn} - f_{c_1}) = n f_{max} + (n-1)\Delta f_g}$$

- FDM is also possible in FM and AM
- We have studied for AM.

Date

Example FDM.

- Consider TV channels or Voice Signals
- Let $f_{c_1} = 100\,KHz$.
- Medium Bandwidth $= 5MHz$ (f_{cm})
- Calculate no. of channels used
- Given $\Delta f_g = 100\,KHz$

$$\boxed{f_{cm} - f_{c_1} = n\, f_{max} + (n-1)\Delta f_g}$$

$\Rightarrow$ $5\times10^6 - 100\times10^3 = n \times 20\times10^3 - (n-1)\times 2\times10^3$

$\rightarrow$ This value's FLOOR FUNC. gives us the no. of channels i.e $\lfloor n \rfloor$

Cross check { Note : Medium Bandwidth $\neq$ Bandwidth used

FREQUENCY MODULATION

- In frequency modulation, frequency of the carrier wave is varied w.r.t the frequency of the original signal, phase and amplitude are kept constant

$s(t)$: $S\sin 2\pi f_s t$

$c(t)$: $C\sin 2\pi f_c t$

Frequency Modulated Signal

$$c(t)_{mf} = C\sin(2\pi(f_c + K_f\, s(t))\,t)$$

K_f : Constant of FM

$= C \sin(2\pi(f_c + k_f(S \sin 2\pi f_s t))t)$

Applying Complex Engineering Mathematics like Gamma, Basis, eqⁿ (etc)

$\Downarrow$

A large no. of sine wave

- Frequency Domain Representation

- The large no. of sine waves we get span over frequencies from $-\infty \longrightarrow \infty$

But, the Amplitude (A) of these frequencies decreases as the frequency increases / decreases.

- Now $\lim_{n \to \infty} \frac{A}{n} = 0$ i.e Power becomes 0

- It is seen Practically that after $n > 5$ Amplitude becomes very small.

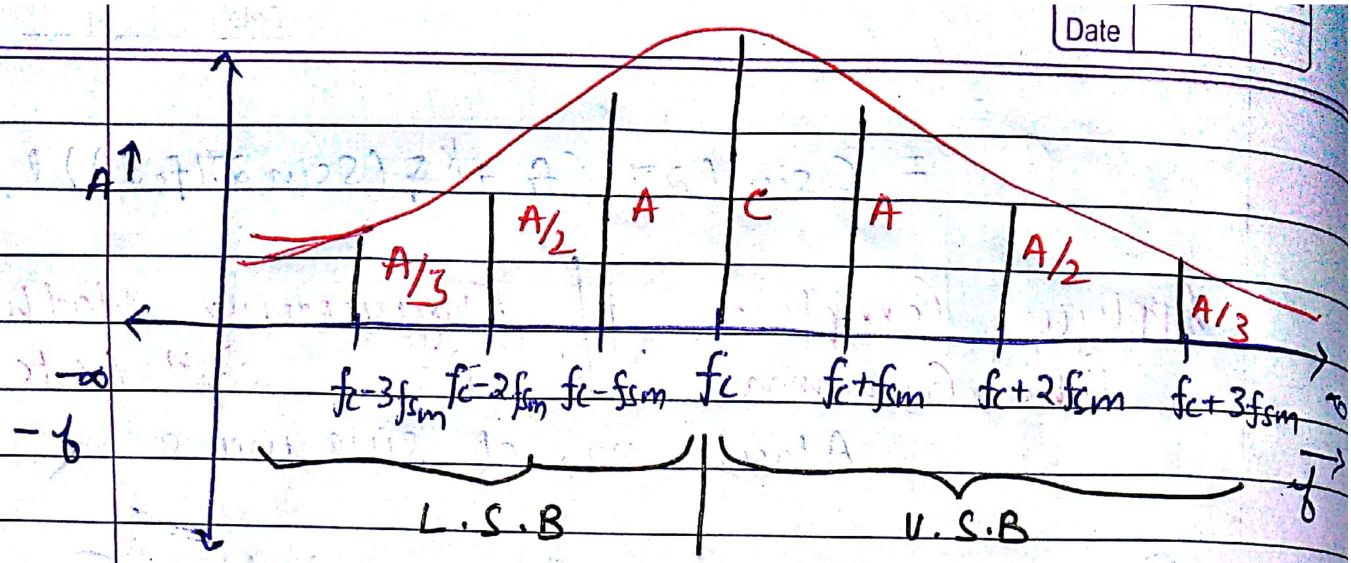
$f_s = f_{max} = f_{sm}$ [used Interchangeably]

Amplitude : $f_c \Rightarrow C$

$f_c \pm f_{sm} \Rightarrow A$; $f_c \pm 2f_{sm} \Rightarrow A/2$

$f_c \pm 3f_{sm} \Rightarrow A/3$

Date



- Required Bandwidth Original Signal

$$B/W_s = f_{sm}$$

- Bandwidth modulated Signal in FM

$$B/W_{fm} = L.S.B + U.S.B$$

$$= 5f_{s\,max} + 5f_{s\,max}$$

$$\boxed{B/W_{mf} = 10 f_{max}} = 10 f_s = 10 f_{ms}$$

- Here also we only use U.S.B.

- Required Bandwidth Effective

$$\boxed{B/W_e = 10 f_{max}}$$

Page No.
Date

F.D.M in F.M.

Let f_{c_1}, f_{c_2} - - - be the carrier frequencies of the channel

$$f_{c_1}, f_{c_2} = f_{c_1} + 5 f_{max} + \Delta f_g$$

$$f_{c_3} = f_{c_2} + 5 f_{max} + \Delta f_g$$

$$\boxed{f_{c_n} - f_{c_1} = 5n f_{max} + (n-1)\Delta f_g}$$

given medium Bandwidth

$\boxed{n}$ = No. of Channels

Why Quality of FM > AM ?

In AM atmospheric noise is also modulated i.e AM is more susceptible to noise.

In FM quality is much better.

16-2-18

Phase Modulation

$$C(t)_m = C \sin\left(2\pi f_c t + \phi_c + K_p s(t)\right)$$

$s(t) = S \sin 2\pi f_{max} t$

- Earlier we had taken phase as 0. Now it isn't.
- In sine 2 things are changing

sinosudial + linear

This is highly complicated.

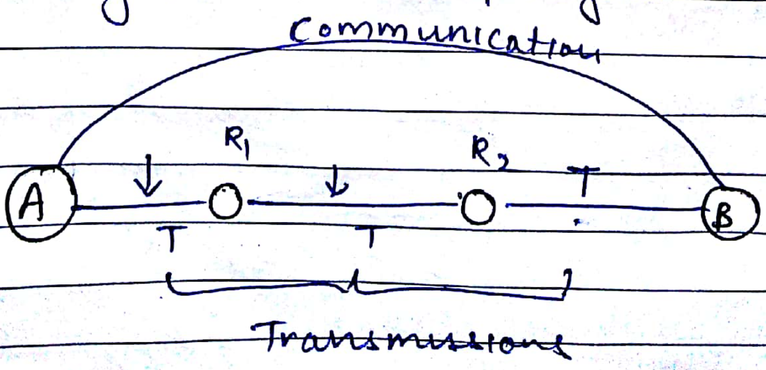
Thus, phase modulation is not done.

x ———— x ———— x ———— x ———— x ————

	Signal	Carrier	Modulated Carrier	Transmission	Communication
	Analog	Analog	Analog	Analog	Analog
Eg:	Voice Music AM, FM				

Note: transmission vs communication

medium mai signal ko dalna	end to end Higher level term



Page No.
Date

AM → Mono channel recording ∴ Quality isn't good
FM → Stereo Channel - (2) channels

Now, For FM = 20 KHz - (to be sent)

Both are sent separately

left speaker — right speaker

FM
* Bandwidth = 5 × 20 KHz + 5 × 20 KHz = 200 KHz

Now, moving on to TV

TV → Music → Audio (20 KHz)
Picture → Video (5 MHz) } ← Amplitude Modulation

like this cases are discussed

- Case 1) TV - Music } Amplitude (AM) · 020 KHz
  Picture } 5 MHz
  Total BW = 5.02 MHz

- Case 2) TV → FM - 0.200 MHz } = 25.2 MHz
  FM - 25 MHz
  ↓
  Not Permissible ∴ very expensive

Eg: video with AM mixer / juicer visible in TV screen

Thus we move to the alternative below

Date

Music — FM = .02 MHz

Case 3) TV — Video — AM = 5 MHz = 5.2 MHz

This is preferable ∵ audio will be good. As $\left(\frac{.02}{.2}\right)$ negligible to 5 MHz

Thus, in TV

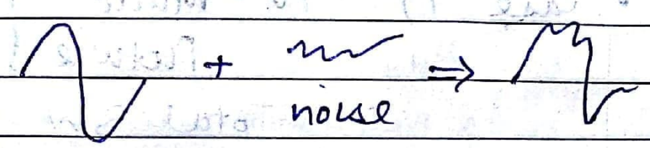
Video — AM

Audio — FM with Stereo

Reasons for this { Music quality becomes high
.18 negligible to 5 MHz

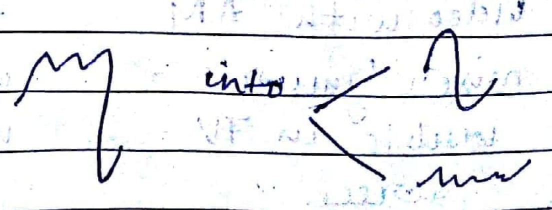
	Signal	Carrier	Modulated Carrier	Transmission	Communication
TV : (music) (Audio)	Analog	3 carriers Analog	"	"	"

(Q) What is the problem with Analog?

Ans) In analog 

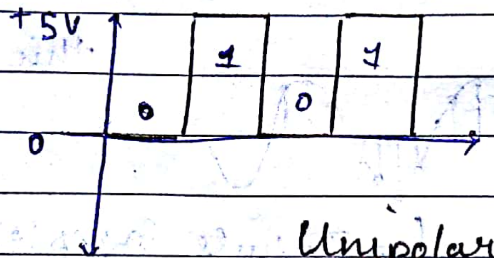
At the reciever end we can't remove the noise.

∴ of this people prefer digital transmissions (+ some other benefits)

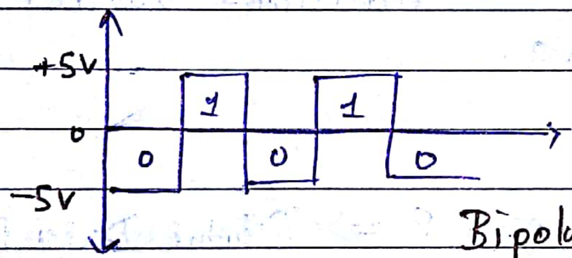
No Mechanism to separate 

DIGITAL COMMUNICATION

- Naturally occuring digital signal — In Computers (Alpha-Numeric Data)



Unipolar Encoding



Bipolar Encoding

- Original Audio → Analog
  Video → Analog (No. of Images)
  Image → Analog

* advantages of Digital — will be discussed later

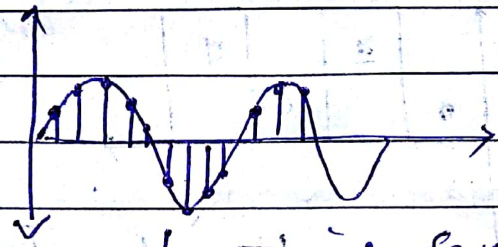
Now, by some mechanism
Audio, Video, Image } Analog → Digital (Transform)

[Now, everything is stored in computer as alpha-numeric DATA
everything becomes data in Digital]

CONVERSION OF ANALOG MUSIC to DIGITAL MUSIC

Music Analog – 20 KHz

Suppose



this our Analog Signal

↳ Infinite Samples for 1 cycle . to make a continuous values (digital)

Each analog value corresponds ← to 8 / 16 bit value.

[Actul Analog]

for T sec – $\alpha \times 8$ ⇒ Digital Data Rate = α

Here, Nyquist Criteria helps

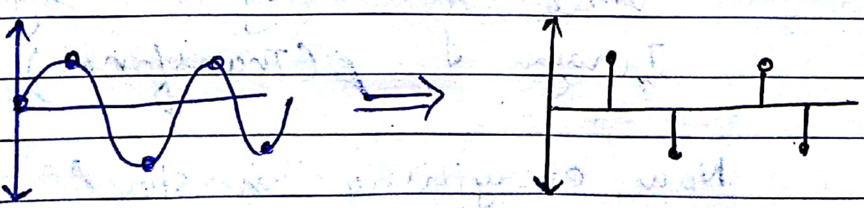
For nyquist in T sec → only 2 sample

Let 8 bit → 1 sample

Data Rate

$$T\,sec - 2 \times 8$$

$$1\,sec \longrightarrow \frac{2 \times 8}{T}\ \text{bits}$$



Now, how do we get back original Analog

Page No.
Date

As $\boxed{\text{frequency} \propto \text{No. of Sampling}}$

When we us Fourier to get back we get back original signal + some very high frequencies

$\downarrow$ pass through FILTER

get original signal.

* Note :- } This rate of change is stored for reconstruction

Now suppose

20 KHz → 2 per cycle
→ 2 × 20 000 /second

* Thus,

DATA Rate = 2 × 20 000 × 16 bbs
= 640 K bps.

for Stereo transmission

data rate = 2 × 640 K bps
= 1280 K bps = 1.280 Mbps

This is uncompressed value ←

Thus, we use mechanism of compression like MP3, thus data rate will reduce.

* $\boxed{\text{DATA Rate} \propto \text{Bandwidth}}$

- Only in channel compression takes place.

Page No.
Date

Remember : Music Analog = 20.5 KHz (Actual value)

For simplicity we are using ~~2000~~ 20 KHz.

For Telephone

telephonic voice

Bandwidth = 4 KHz

No. of Samples = 2 × 4000

Data Rate = 2 × 4000 × 8

= 64 Kbps

1 sample requires = 8 bits

Ignore ———x———x———x———x———

voice (mono)

BW (Hz)	Digitized (bps)
4 KHz	64 Kbps)

———x———x———x———x———x———

⇓ Carried out

	BW (Hz)	Digitized (bps)
Voice (mono)	4 KHz 4 K cy/s	64 Kbps
Music (Stereo)	20 KHz × 2	1.280 Mbps
Video		

compression ?? ??

* Note BW is only imp in transmission medium

Video Digitization

- Aspect Ratios — Initially 4:3

- Earlier we had VGA, now we have HD

4:3 — Not Flatscreen

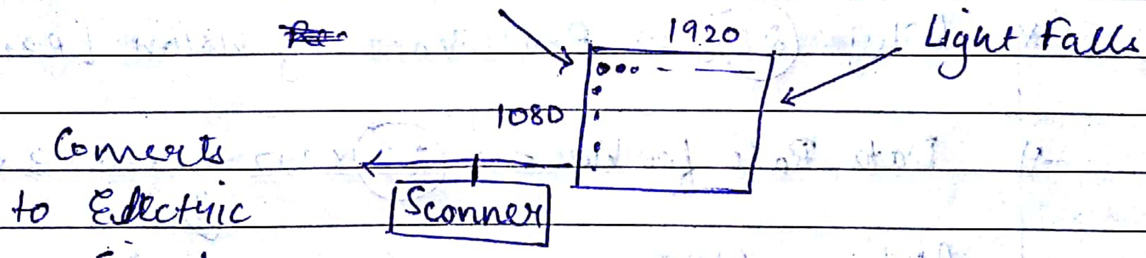
1920:1080 — Flatscreen (16:9) FHD

- For a single photo → Capture 1920 × 1080 pixels
- Each point is RBG

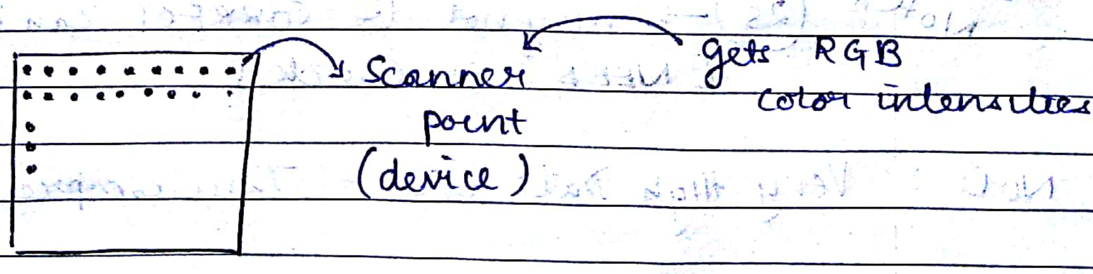
So no. of points = 1920 × 1080 × 3

To understand, this we move to the concept of video Camera.

- In video camera, we have photo sensitive area
- Photo sensitive Screen



1st in analog form → convert to → Digital



Scanner – takes RGB color intensity light as I/P. Gives out analog electric signal.

- It uses 3 filters $\left.\begin{matrix} R \\ G \\ B \end{matrix}\right\}$ Encode thus { 8 bits each

- Thus for each pixel (RGB) point, we need
  $= 3 \times 8$ bits $= 24$ bits

- No. of pixels $= 1920 \times 1080$

- Total Bits $= 1920 \times 1080 \times 3 \times 8$ bits

- Hence, we use COMPRESSION

  Lossy Compression
  (Some loss of Quality)

For Video : send 25 such images [FRAMES]

* Why 25? ⇒ Persistence of vision [Reason]

Data Rate for Video : $25 \times 1920 \times 1080 \times 3 \times 8$ bps
⇓
Compressed using MPEG4 (MP4)

Audio – MP3

Imp Note! 25 ⟶ may not be CORRECT can be 50
[NEED to Check]

Note : Very High Date Rate – Thus compression is used.

- No. of Colors Possible $= 256 \times 256 \times 256$

Date

WHY we Go from ANALOG to Digital?

(1) Noise / Error detection and Error Recovery is possible in Digital Form not in Analog.
[DISCUSS Later]

(2) The digital signal can be stored and processed in digital computer not in Analog
[ANALOG PC's are now obselete]

~~(3)~~

Digital Computer

can run [i.e store and process]

multiple Applications

General Application
Eg: reservation systems, etc

Special Application

[From comm^n point of view]

(1) Compression
(AT Transmitter)

Decompression
(at reciever)

(2) Encryption
(at transmitter)

Decryption
(at reciever)