ADVANCED COMPUTER NETWORKS : MCS 204

2/1/19

Computer networks
- wired network – wire midium
  - LAN
  - MAN
  - WAN
  - electrical signal → voltage, current
    - unshielded Twisted Pair
    - Coaxial Cable
  - optical fible (signal – (~~light~~) light)
- wireless (propogate → space medium)
  - signal ↓ E field, H field — called as electromagnetic wave (cannot travel through conductor and reflects but can pass through insulator)
  - Airo space
  - Absolute space ↓ solid medium ↓ wood, water
  - insulated medium (Dielectric medium) X

metallic box se E-M wave travels ni karti-?

8/1/19

Insulator (Dielectric Medium)
- wood, water, air
- space

Width of a road. is the bandwidth
↳ jitna broad utne channels

Tanenbaum

→ wireless signal generation, propogation and reception
→ modulation Techniques
→ Multiple access schemes

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& data

→ Mobile voice, communication → 1G
2G (GSM) + GPRS & EDGE
3G →
4G

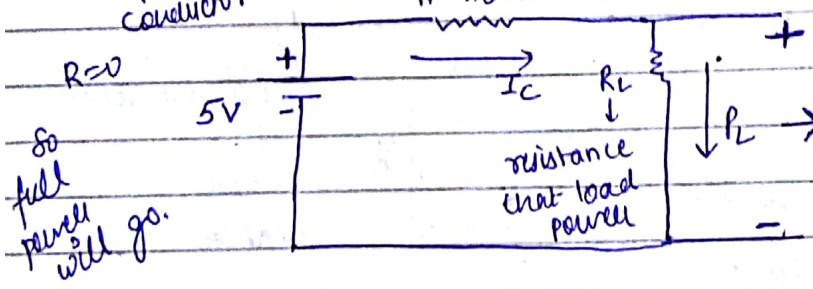
→ wireless LAN — wifi
a, b, g, h, n
Platforms.

11/1/19

Wired Circuit

instead full conductor ← R Resistance → yha power lost hoga we should minimize it

V_L → output voltage

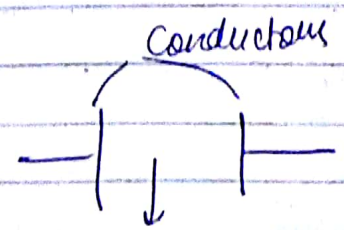


$$I_C = \frac{V}{R+R_L}$$

$$V_L = I_C \times R_L$$

$$P_L = V_L \times I_C = I_C^2 \times R_L$$

Capacitor



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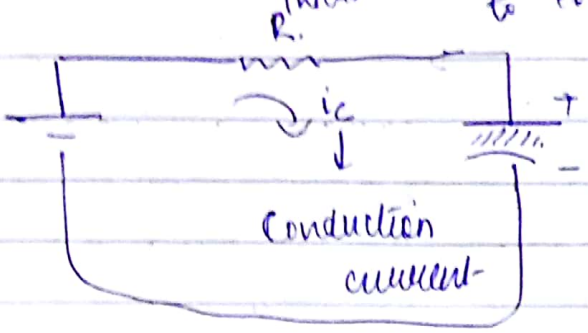
internal R low hoga to external R.



Q → charge in capacitor

C → charge

$$V_C = \frac{Q}{C} = \frac{1}{C}\int_0^t i_c\, dt$$

Capacitor cannot be charged continuously.

When $t = 0$ switch on kia to capacity of pe charge nhi hoga.

$$I_{c(0+)} = \frac{V}{R}$$

when $t = 0$.

when t is something then time ~~with become change~~ Capacitor charge hoga.

$$I_c = \frac{V - V_c(t)}{R}$$

After some time capacitor me poora charge aa jaega to ~~resistance~~ Resistance across charge 0 ho jaega

current → to

electrons ← direction me flow hota hai

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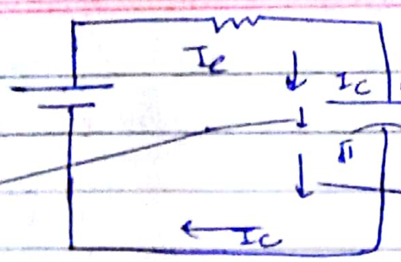


change yha aake deposit ho jaega *

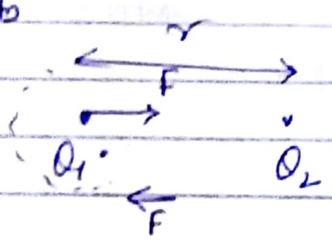
insulator hai to current

yha kaise jaega

we can assume ki imaginary current ja rha hai and we call displacement current.

* to jo plates neutral hai usme free charge aa jaenge to electric field set ho jaegi aur dusri plate ke charge ko repel kar dega usse current travel karega

Coulombs



~~dielect~~

conductor – conductivity

insulator → permittivity

$$F \propto \frac{Q_1 \times Q_2}{r^2}$$

$$\vec{F} = \frac{1}{\epsilon} \frac{Q_1 \times Q_2}{r^2}$$

ϵ ↓ Permittivity of the medium/ ~~the~~

1C unit charge experiences force from Q is an electric field

$\dot{Q}$ → F

F ↓ na keh ke E kehenge

$$\vec{E} = \frac{1}{\epsilon} \cdot \frac{Q \times 1}{R^2}$$

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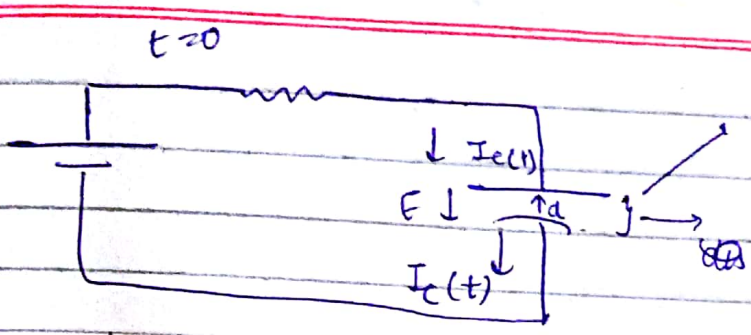
W. = F x d
= E x d

Jha electric field hai wha voltage hoga.



voltage
how much work to be done to move a unit charge

Voltage do points ke beech hoti hai

Electric field ata point krke hai

when same t.

$I_d(t) = I_c(t)$

$I_{c(t)} = 0$ hota jaega

~ → alternating voltage

Voltage at a point is infinity se unit charge ko Lana is plate tk

unit charge ko leke ayenge

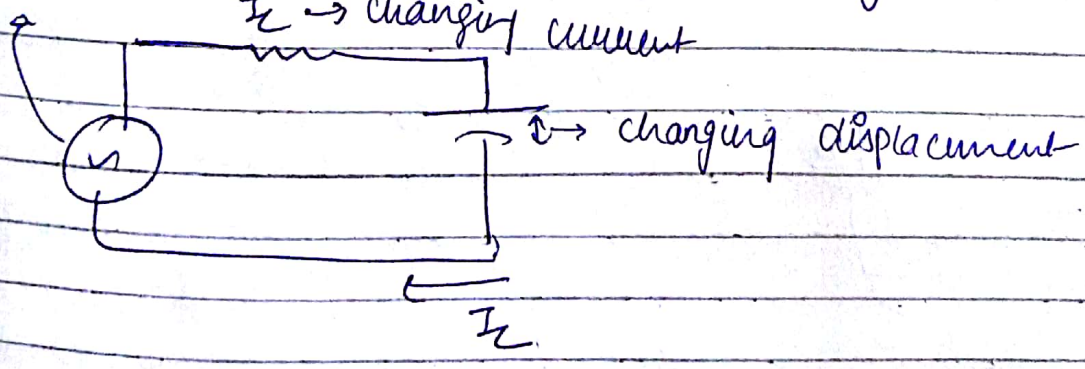
Opposite use se to E change hoga to integration kaenge

V_2

V_1

$V_2 - V_1$ is the voltage to get a point from plate I to plate II

charging voltage



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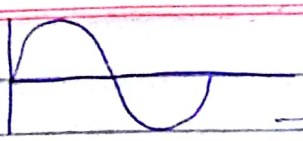
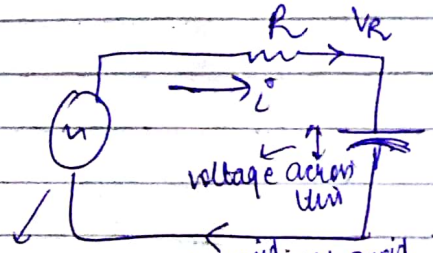
sunosoid - 6



→ this wave 6

When I have a sunosoid voltage
RC-circuit



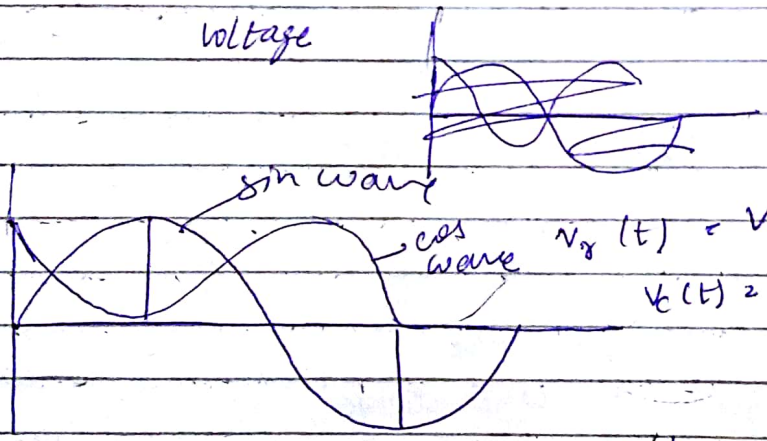
$V_{R(t)} = i(t) * R$

$V_C(t) = \frac{1}{C}\int_0^t i(t)\,dt$

this grows as the current grows

current bhi sunsoid

voltage



$V_s(t) = V \sin 2\pi t$

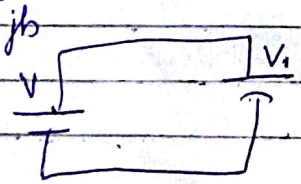
$V_c(t) = -\cos 2\pi t$

$\cos\phi = \sin(\theta + \pi/2)$

jb static voltage hai

to

jb



$V = V_1$

hoga to current flow hona bnd ho jaega

but in case of alternating voltage

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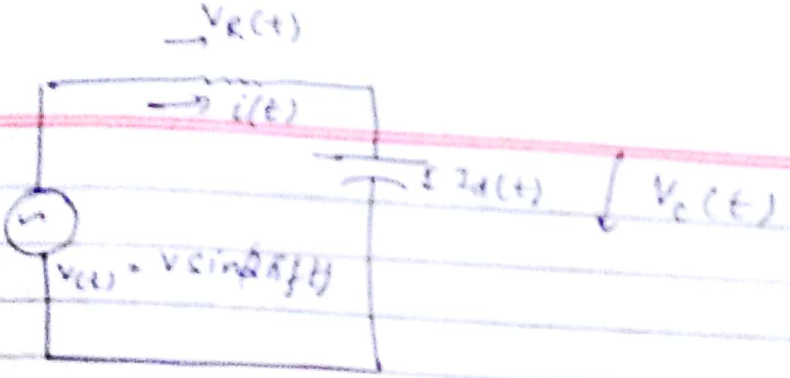

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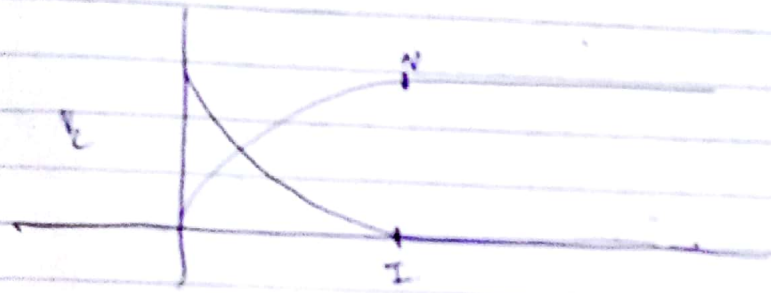
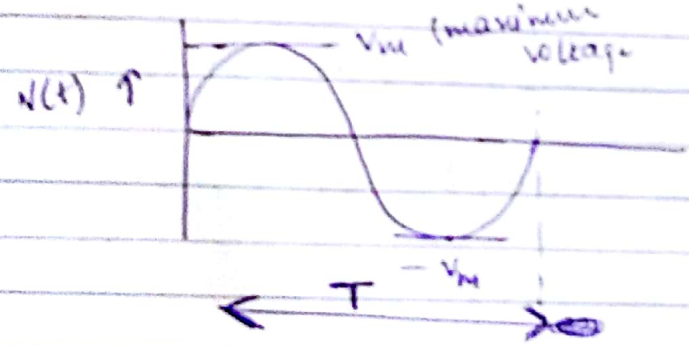




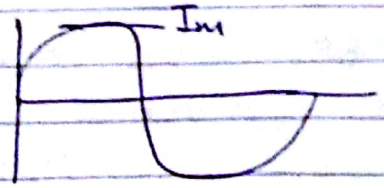
$$V(t) = V_m \sin 2\pi f t$$

$$= V_m \sin 2\pi \frac{1}{T} t$$

Alternating voltage

$$i_c(t) = I_m \sin 2\pi f t$$

$$V_R(t) = i_c(t) \times R = V_R \sin 2\pi f t$$



$$V_R = I_m \times R$$

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$V_c(t) = \frac{Q(t)}{C}$

Thus voltage in capacitor is change

Since change is continuously changing so integration

$$V_c(t) = \frac{1}{C}\int i_d(t)\,dt$$

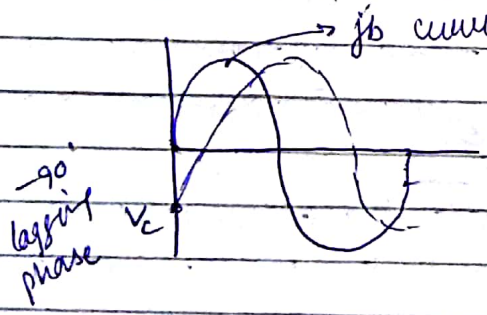
Current across the capacitor differential of $i_d(t)$.

$$i_c(t) = i_d(t)$$

$$V_c(t) = \frac{1}{C}\int I_m \sin 2\pi f t\,dt$$

$$= -\frac{I_m}{C}\cos 2\pi f t$$

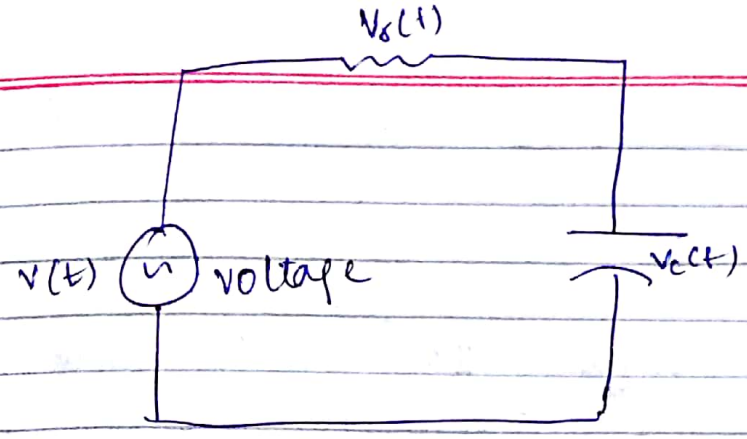
$$V_c(t) = -V_c \cos 2\pi f t$$



→ jb current thuro hua voltage across capacitor is ne

voltage across capacitor is sunosoid but not same sunosoid as current. with different phase

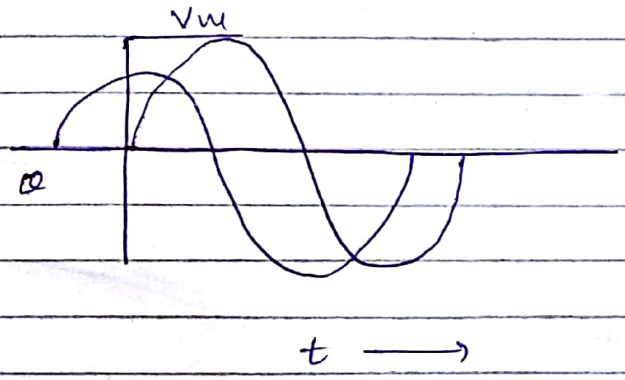
voltage and current across resistor is sunosoid voltage across capacitor is ↗ width different phase



$$V(t) = V_R(t) + V_c(t)$$

$$V_m \sin 2\pi ft = i(t) \times R + \frac{1}{C}\int i(t)\,dt$$

$i(t)$ phase will be different



$$i(t) = I_m \sin 2\pi (ft + \phi)$$

$$= \frac{V_m}{R^2 + \left(\frac{1}{C}\right)^2 \theta} \quad \theta = \tan^{-1}\frac{R}{\frac{1}{C}} = RC.$$

pure tone / signal → ek hi frequency phase

bandwidth

Medium ki $BW_m = 5f$

signal ki $BW_s = 10f$

nhi jaega distortion hoga

$BW_s \leq BW_m$

vo pass kar jaega

chaie frequency ka phase kuch bhi ho.

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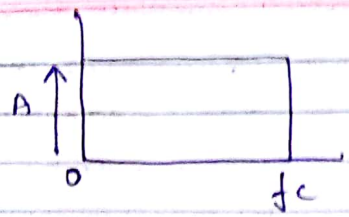
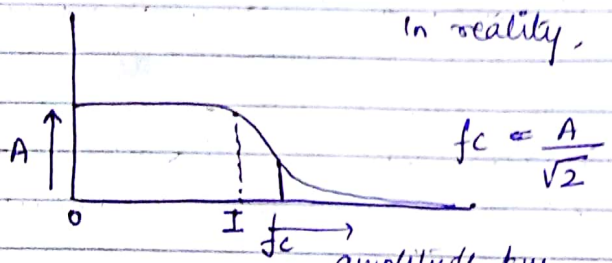


eg. max frequency that can be passed from the medium is fc.

So signal with bandwidth $\leq f_c$ will be passed without distortion

In reality,



amplitude km hota rhega

original power is

$P = KA^2$

fb medium se pass hua

I th power me much degradation ni hega

pass after I the amplitude will start decrease

$$k\left(\frac{A}{\sqrt{2}}\right)^2 = \frac{KA^2}{2}$$

half power point

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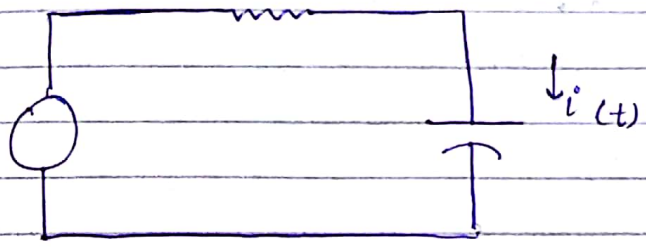
Composite frequency signal — consisting of many frequencies

Behaviour of communication medium is frequency sensitive
higher frequency — power loss hota hai
is lie communication medium ka ek frequency
hota hai usse zyada bheja to powerloss.



$i(t) = I_m \sin 2\pi f t$

$V_r(t) = R \times I_m \sin 2\pi f t$

V_m

Voltage se bhi aise karenge

$$\frac{V_R(t)}{i_R(t)} = R$$

doesnot discriminate frequency

It considers every frequency the same

$$V_c(t) = \frac{1}{C}\int i(t)\,dt$$

$$= \frac{1}{C}\int I_m \sin 2\pi f t\,\partial t$$

$$= -\frac{I_m}{C 2\pi f}\cos 2\pi f t$$

$$\frac{V_c(t)}{i_c(t)} = \longrightarrow$$

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nullah nhi hai phase ki wajah

$$\frac{V_c(max)}{I_c(max)} = \frac{I_m}{2\pi f C} \cdot \frac{1}{I_m}$$

$$= \frac{1}{2\pi f C} = X_C \rightarrow \text{reactance of capacitor}$$

$\frac{V_s(t)}{i_s(t)}$, R → constant
donot change with frequency.

more X_C less current-

$$\frac{V_c}{I_c} = X_C$$

$$\frac{V_c}{X_C} = I_c$$

$X_C \cdot \frac{1}{2\pi f C}$

C
I constant

zyada capacitance value
X_C will be less
I_c will be zyada

$\frac{1}{2\pi f C}$, X_C

↓

increase X_C decrease
so current increases

Higher Frequencies ko kaise block kar sha hai

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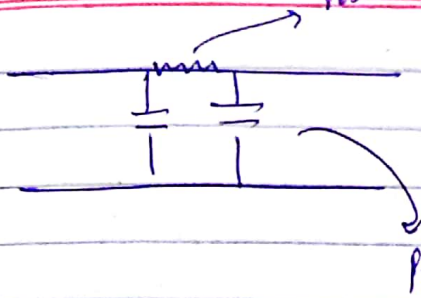
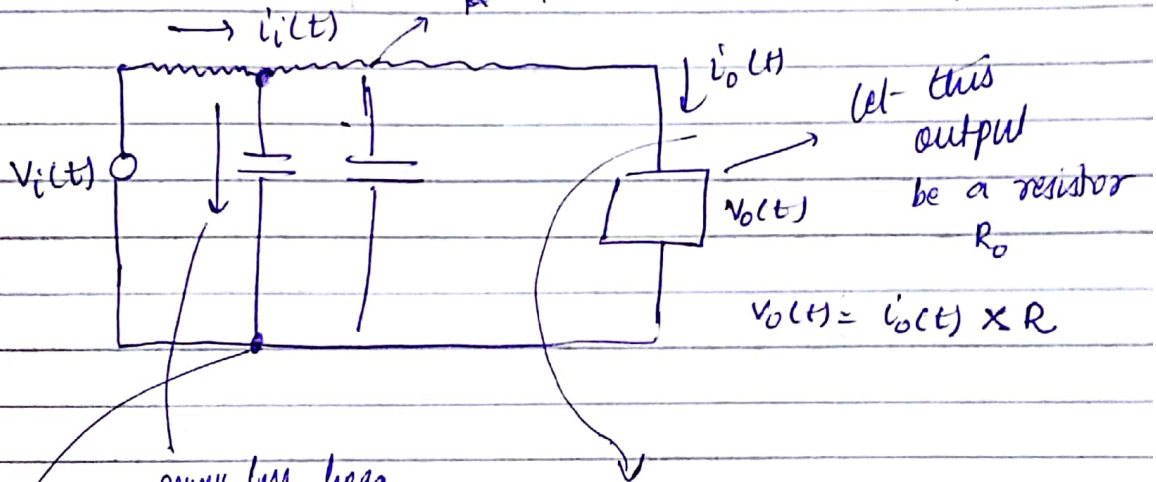
Twisted Pair



R. ~~per~~ resistance is same for all frequencies



$\frac{V_c}{X_c} \rightarrow I_c \uparrow$ leakage current

$f \uparrow \; X_c \uparrow$

different frequencies hai

let

$i_i(t)_f = 10\,A$ $\qquad$ $i_o(t)_f = 8A$

because of leakage ki wajah se

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$V_o(t)_f$ = 8 × R_o ↑ the frequency ↓ output voltage

$V_o(t)_{2f}$ > 7 × R_o

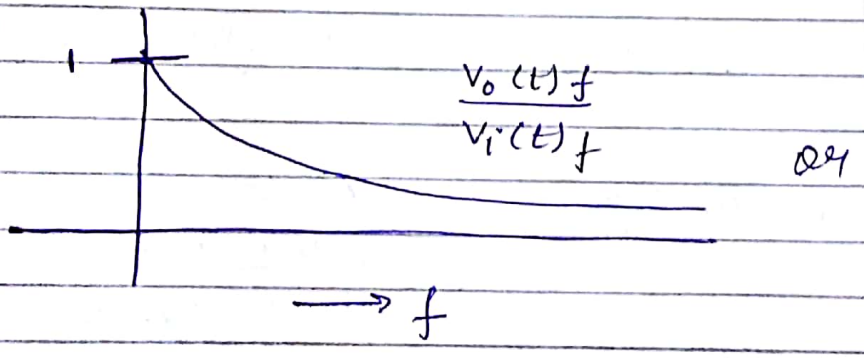
Gain factor = $\frac{V_o(t)_f}{V_i(t)_f} < 1$ → constant for all frequencies

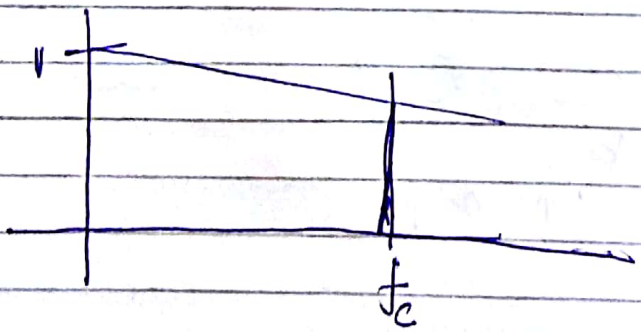
0 frequency

$$g = \frac{V_o(t)_f}{V_i(t)_f} = 1$$

↓

capacitance ni hoega.





agar capacitance ni hota to infinite bandwidth

power is half of the original

Cable ki bandw – 1GHz

So signals of frequency > 1GHz attenuation zyada hoga and signal distort-hoga.

signal to carry information must change

laws of superposition

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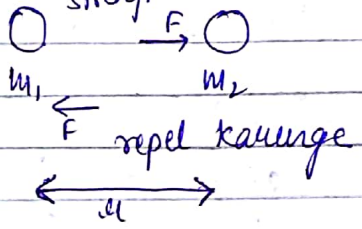
Magnetic Field

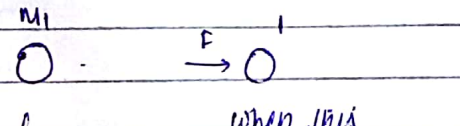
According to the law of magnetic law of attraction

$$\vec{F} = \frac{\mu m_1 m_2}{d^2}$$

μ ↓ permiability of the medium

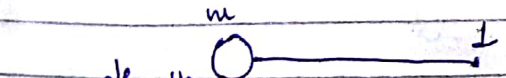
north pole strength





when this is not there

yeh koi bhi force lgaye pta ni lageya



jb yeh 1 point → to H hoga ins tead of F

$$\vec{H} = \frac{\mu m(t)}{d^2}$$

↓ time varying

$$\vec{h}(t) = \frac{\mu m(t)}{d^2}$$

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$m(t)$ varying in sinosoid manner.

others are constant

$$m(t) = M \sin 2\pi f(t)$$

So

$n(t)$ is varying

$$\vec{E} = \frac{1}{\epsilon} \frac{Q}{4\pi^2}$$

ϵ ↙ Permittivity

↓ time varying

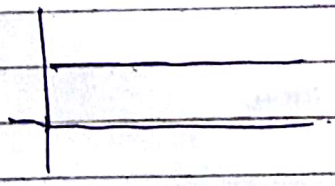
$$\vec{e}(t) = \frac{1}{\epsilon} \cancel{Q(t)} \frac{q(t)}{4\pi^2}$$

(to yeh bhi)

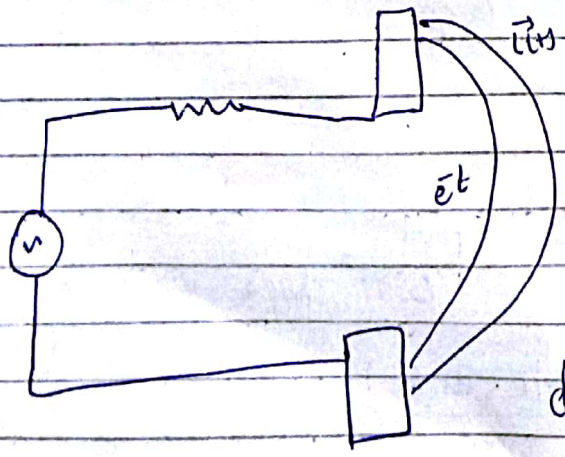
$$q(t) = Q \sin 2\pi f t$$

↓ yeh sinsoid

DC frequency 0 ~~time~~ change ni hota



$$f = \frac{1}{T} = \frac{1}{\infty}$$



$$\vec{e}(t) = E \sin 2\pi f t$$

$$i_d(t) = I \sin 2\pi f t$$

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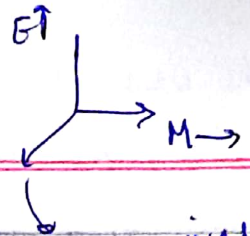
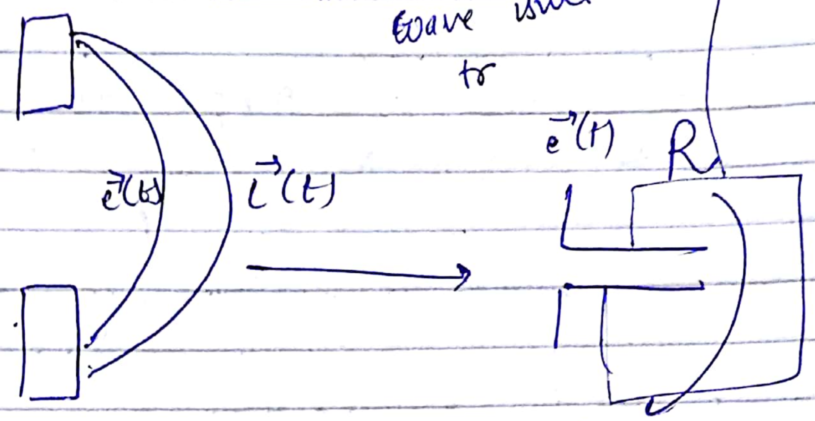
magnetic field bhi generate hoga

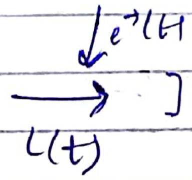


wired circuit hai

Transmitor antenna



Catches wave ~~electri~~ ~~electric field~~

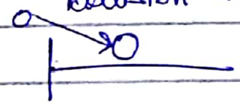


] will induce voltage

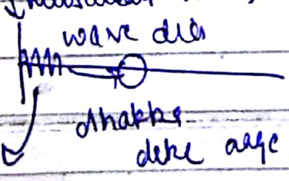
Electric & Magnetic field changes while going to the receiver.

Water Waves

energy propogation
- particle propogation → new particle move
- wave propogation



energy transfer energy and other stone will move particle propogation



particles does not move

particles energy shift karenge

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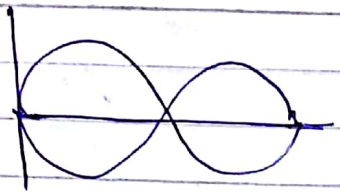
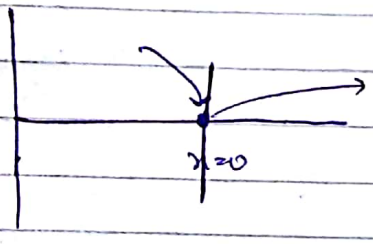
Bigger the mass less wave nature more particle nature
Smaller the mass more wave nature less particle nature.

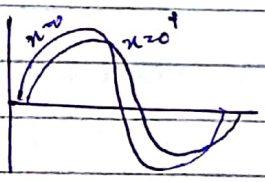


2 light with same frequency
different phase
produces darkness.

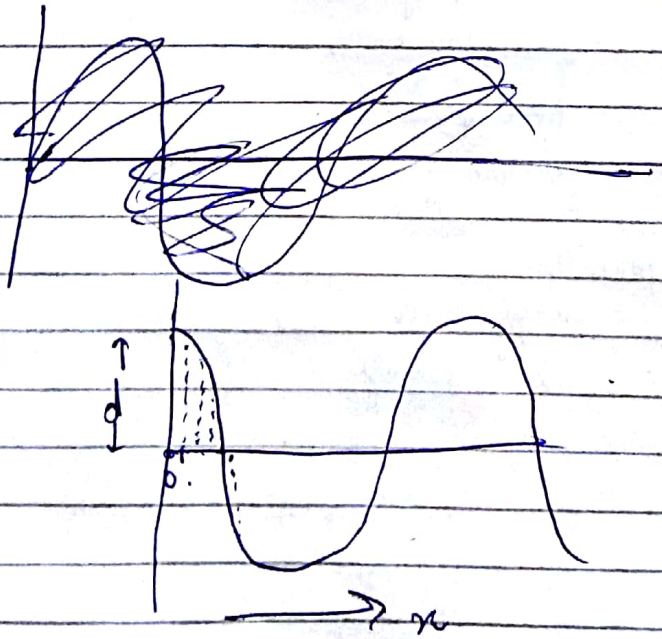
dual nature of light.



water particles
oscillate
causes
apne neighbours
to energy denge



particle is not moving
only energy is transferred.
and particles start oscillating



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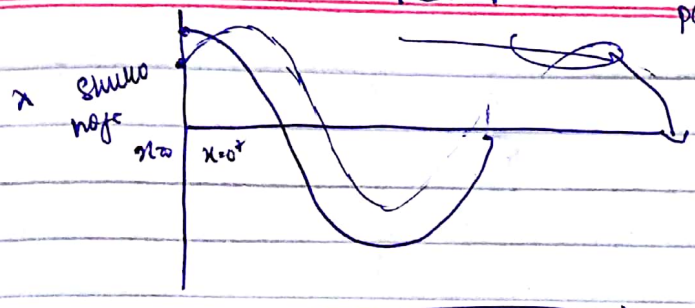
jb $x=0$ particle peak pe hai to dusra particle abhi shuru hoga



aur $x=0$ particle phir neeche ayega

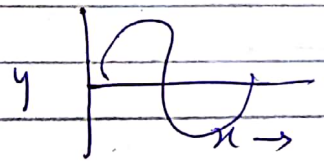
peak aage jaega

to $x=0^+$ particle peak pe ayega

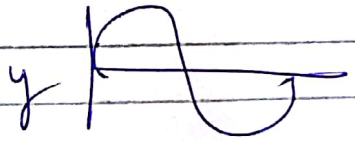
wave front bolte hai

above the surface

$y \rightarrow$ function of time & distance



looking y with x will also be sin wave



looking y with t will also be sin wave.

$$y(t,x) = Y \sin(2\pi f t \mp \beta x)$$

↑ max peak length

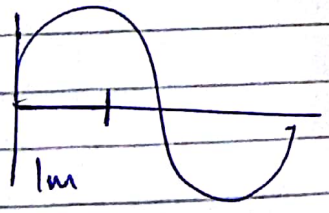
↓ phase change by unit distance

when $x=0$

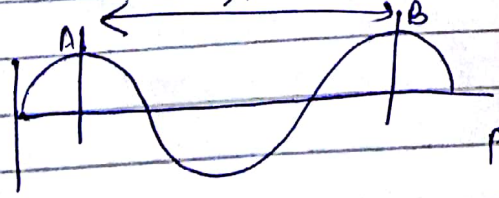
$Y \sin(2\pi f t)$

$x = x_1$

$Y \sin(2\pi f t - \beta x_1)$



we jitna phase change hua use β krenge



phase b/w A & B is 0.

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λ distance pe 2π phase change

$$1 \longrightarrow \frac{2\pi}{\lambda}$$

$$\therefore \beta = \frac{2\pi}{\lambda}$$

$$y(t,x) = Y \sin\left(2\pi f t - \frac{2\pi}{\lambda} x\right)$$

$$\vec{e}(t,x) = E_m \sin\left(2\pi f t - \frac{2\pi}{\lambda} x\right)$$

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

antenna se field varying hai

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$$\vec{e}(t,x) = E_m \sin\left(2\pi f t - \frac{2\pi}{\lambda} x\right)$$

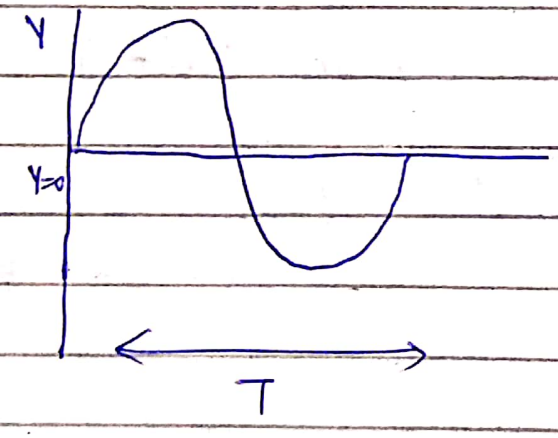
$$\vec{h}(t,x) = H \sin\left(2\pi f t - \frac{2\pi}{\lambda} x\right)$$

antenna se field varying hai

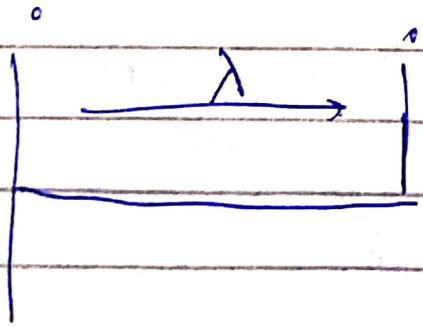
29/1/18

Function of t → water particle movements

$$y(t,x) = Y \sin\left(2\pi f t + \frac{2\pi}{\lambda} x\right)$$



$$f = \frac{1}{T}$$



1 sec — λ m (distance)

1 sec — $\frac{\lambda}{T}$

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$f = \frac{1}{T} = \lambda$

$V = \lambda f$ (velocity of wave)

Electro Magnetic Field

$$\vec{e}(x,t) = E \sin\left(2\pi f t + \frac{2\pi}{\lambda} x\right)$$

magnitude is changing sine ~~soide~~ soid

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

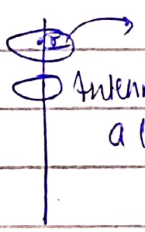
~~Equal points are in a ckt~~ (phase ko join karne pe)

Wave Front will form a circle

If the distance increases then the wavefront will become a line.

↓

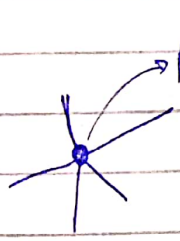
that will be a line wave or a plane wave



r increases then it will become a plane then a plane wave

a line then we will a cylindrical wave

If antenna



wavefronts will be spherical so spherical wave.

distance away from atenna ~~plane~~ wave is coming as a plane

$V = f\lambda$

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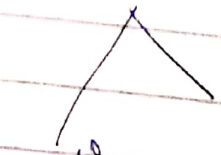
Signal → whatever we are passing through a medium (space)



Audio

Human produced by larynx

100 KHz range

Signal

TV (Analog)

Audio + Video

20KHz + 5MHz

(5.02 MHz)

Simplicity

(5.1 MHz)

Audio (Analog)

Telephone (landline)

300Hz - 4KHz

very low so

0Hz - 4KHz

BW = upper - lower

= 4KHz

Music

300Hz - 20KHz

0 - 20KHz

BW ⇒ 20KHz

Video (Analog)

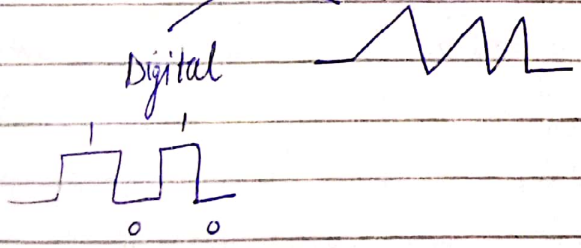
0Hz - 5MHz

BW - 5MHz

Data (Digital)

Signal → Analog → varying continuous

Digital (discrete)



$\lim_{t \to a^-} s(t) = s(a) = \lim_{t \to a^+} s(t)$

continuous at point a

if s(t) is continuous at all a's

↳ analog signal

(many sumoidal signals added together)

Scanned by CamScanner

Signal function of t

then $f(t) = f(t+T)$ $\forall t$

then it is periodic signal

$\not\exists\ f(t+T)$ → non periodic

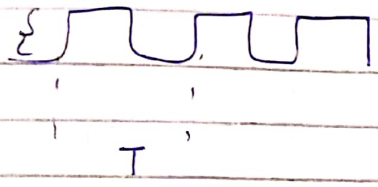
Fourier series

Any periodic (analog / digital) signal

then

$$g(t) = C + \sum_{n=1}^{\infty} A \sin 2\pi n f t + \sum_{n=1}^{\infty} B \cos 2\pi n f t$$

(C → Offset frequency signal)



$g(t) = 0$

$0 < t \leq T/2$

$f = \frac{1}{T}$

$= 5$

$T/2 < t \leq T$

$$g(t) = \frac{5}{2} + k \sin 2\pi f t + \frac{k}{3} \sin 2\pi 3 f t$$

(k → Amplitude)

$BW = \infty - 0 = \infty$

We cannot such medium with high bandwidth

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Signal of high frequency distort hoga but amplitude reduce ho rha hai to power km hoga.

$k \quad \frac{k}{3} \quad \frac{k}{n}$ ↑ increase

$BW_e = 11f - 0$

$= 11f$

frequency ka matlab ni range

9f se 11f - 2

pure tone - 1 frequency

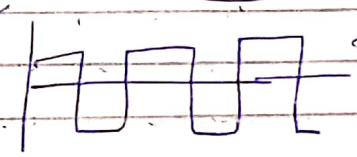
DC - amplitude of 0 frequency

1 frequency signal BW = 0

?

If ni hoga

f, 3f, 5f



Combination ke

→ periodic wave ko divide karunge (using fourier) to they will come from f, 3f, 5f

Since 0 frequency nhi hai to utna signal +ve side pe jaega to utna negative side

Breaks the signal into sin components to frequency spectrum pta lagega, bandwidth

Any signal ko within sine wave

Bandwidth jitni hogi atmost utni frequency the signal bhej pate hai

Composite
- periodic → using fourier series, we can find the frequency of components
- Non periodic → We cannot calculate exact frequencies

signal bheja distort ho hogya to that is

Digital data not

carrier signal

low pass signals

when all radio

hoga so

cannot send directly

Signal

S(t) → Mod

$f_c >$

(hit and trial)

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signal bheja distort hua to bandwidth increase kia agar pass hogya to that is the bandwidth.

Digital data not natural but we are passing have bandwidth

carrier signal → technique by which we send our original signal.

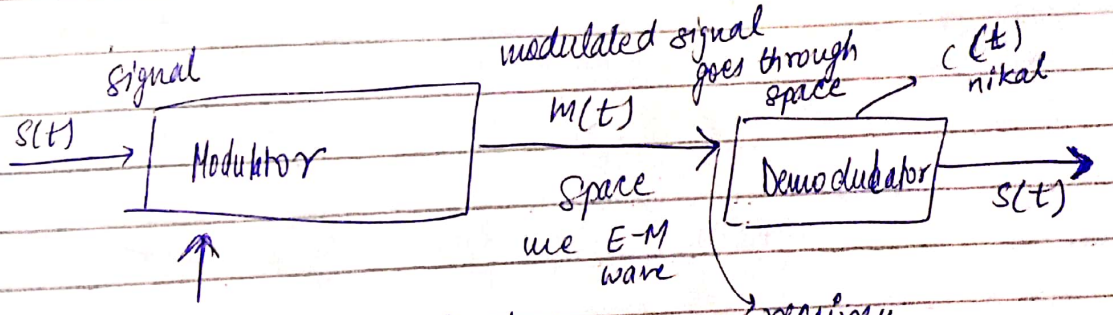
low pass signals.

when all radio signals are passed together to distortion (hoga so I need to send these signals separately

↓ cannot send directly

↓ so send through a carrier signal (modulate it)

and at receiver (demodulate it)



$f_c >> f_{sm}$

(max freq of signal that is passing)

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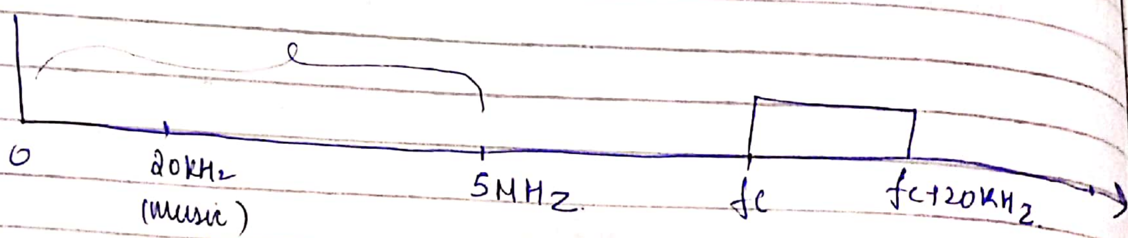
Carrier signals generated through oscillator

What all signals pass through space

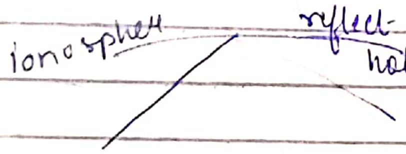
Natural signals



jis carrier signal
add karega jiski
frequency fc hai

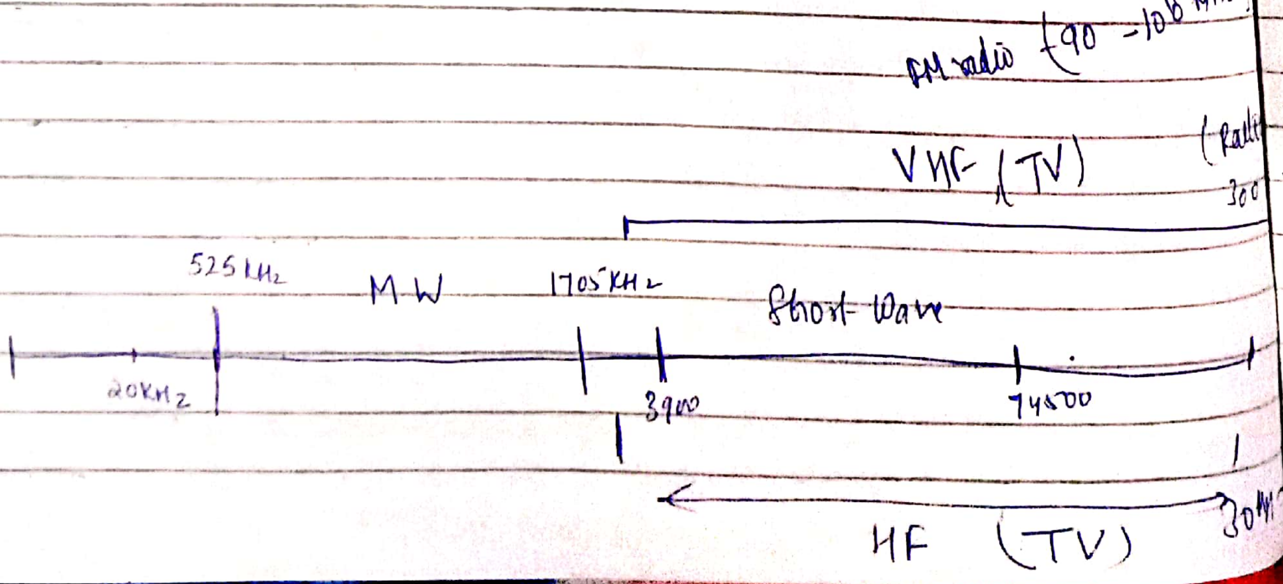
Medium wave — 525 KHz - 1705 KHz
(yeh local hota hai) (radio) (near the surface travel hota hai)

Short wave ⇒ 3900 KHz — 7450 KHz



(for more region cover)

High Frequency wave — 32-30 MHz



1 GHz – 3G | 4G 3G spectrum.
2G spectrum.

VHF – 30 – 300 MHz
UHF – 300 MHz – 3 GHz
(3000 MHz)
→ (890 – 960 MHz) – 2G comm.
GSM mobile communication)
→ 1800 MHz – 1900 MHz (Range check ?)

3000ck
2 GHz and onwards is a micro-wave
↓
(wireless LAN (WIFI) ↙ works in line of sight
very sharp transmission beam
2.4 GHz
2.4 + 0.80 (Bandwidth)
5 GHz → 5 GHz + BW (80 MHz ke aspas)
gas oven ↓ microwave heat-
(microwave oven will operate in)
↓
atom heat uniformally all over
(satellite communication bhi hota hai)

Carrier frequency – 40 GHz
tk generate kar pae hai.

FM)
MHz
(WiFi) L Band – 1-2 GHz
S Band – 2-4
(Satellite Communication) C Band – 4-8
X – use ni
Ku – satellite

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ITU

International Telephone Union
↳ so that no interference
↳ country ko band deta hai
↓
government
then divide
bandwidth to
ISP.

Eg. Optical fibre - 10 GHz BW
apne 100 lagya
then it become
1000 x ... Hz

TV ka
5×10^6

$\frac{1000 \times 10^6}{5 \times 10^6}$

200 channels of TV

FDM

Frequency Division Multiplexing

& audio is pass

$\frac{1000 \times 10^6 \times 10^3}{100 \times 10^3}$

10^7 channels for radio.

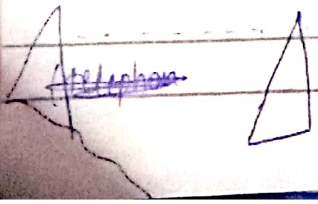
International
↓ — FDM
Nation
↓ — FDM
ISP
| — FDM
↳ within this TDM.

Geostationary satellites.

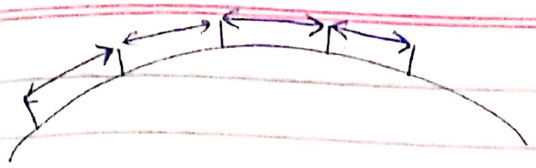
for satellite communication beam should be very sharp

because on reaching satellite it may spread and not reach properly

2 types of line of sight microwave
($3\ GHz^+$)



~~Atelephone~~ terrestrial — satellite



Microwave Propagation Characteristics

→ line of sight communication
→ reflection (metal)
→ refraction
→ interference
(Two way in opp phase — ~~0~~ 0 signal strength)
" " same phase — double strength

Diffraction
here every point is a source so those points will help reflection.
source
light still here
hide

→ Absorbed by Rain, Fog, Trees

Reflection
Interference
reflect ho gya
wall
receive hoga ek aur signal ayega no receive hoga

fading — Multi-path fading → if same phase add nhi to 0.
Distance fading
(Distance increase signal weaken)

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1/2/19

Reflection

Scattered — (Rough Surface)

Regular — (Plane Surface)

Fading

↓

Signal Strength weaks ~~because~~ over distance

Free Space

directly go to receiver (Mobile)

Transmitter Antenna

Receiver

Multi-Path fading

(Some object)

r

x=0 — d — R

(Here the signal strength will be the summation of the r + d.)

signal strength — distance d i.e x

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

$$e_u(t,d) = E\sin\left(2\pi f t + \frac{2\pi}{\lambda}\cdot u\right)$$

$$\bar{e_e} = e_d + e_u$$

($\bar{e_e}$ e effective)

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$r - d = \lambda \rightarrow r = \lambda + d$

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

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

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

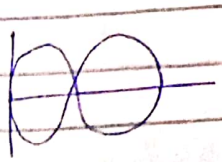
$\sin(\theta)$

2π phase difference gives the same wave

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

$\bar{e}_e(\lambda/2) = 2E(\sin(2\pi ft + 0$

If two waves have ~~same~~ phase difference of $\lambda/2$ so signal strength will be 0



wave strength double — strength 0

Phase difference between $0 \leq r - d < \lambda/2$

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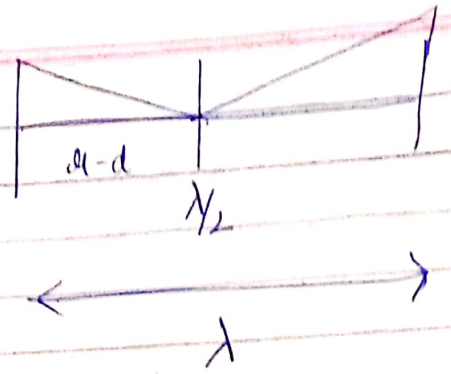

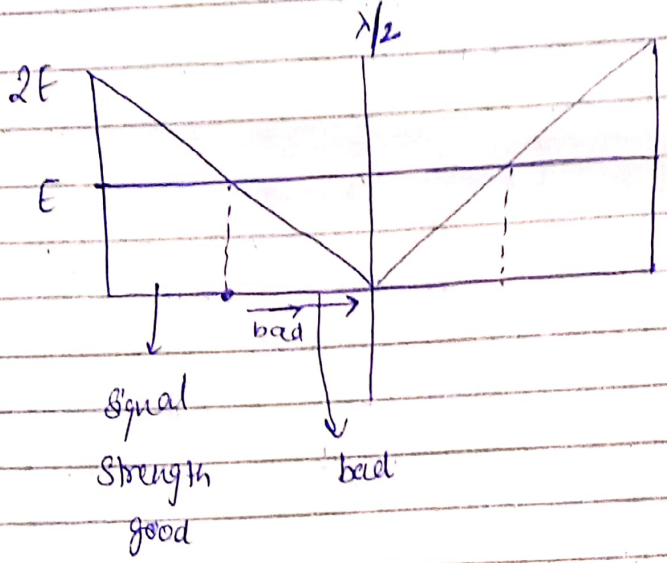

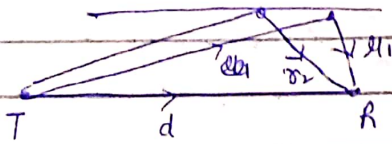

Many ~~do~~ waves
& Reflection many times

So

$\vec{e_d}$: $\delta_1 = \gamma_1 - d = \lambda/2$

$\vec{e_{\delta_1}}$ $\delta_2 = \delta_1 - d - \delta = \lambda$

$\vec{e_{\delta_2}}$

$\vec{e'(\lambda)} = \vec{e_d} + \vec{e_{\gamma_1}} + \vec{e_{\gamma_2}}$ (This is showed graphically bcoz calculations becomes difficult

$e = e_d + e_{\gamma_1} = 0$

$e_e = e + e_{\gamma_2} =$ ~~0~~

(Signal strength same rahega)

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Underground buildings receives less signal because of multi-path fading.

Intrinsic digital signal (~~coming~~ natural)

- Signal
  - analog
    - voice
    - video
  - digital
    - computer data (alphanumeric, data, image)

Voice is 20 KHz (0 - 20 KHz)

Signal is modulated eg. with 500 KHz then modulated signal will become 520 - 520 KHz.

~~Three types of modulation~~ (amplitude modulation) AM

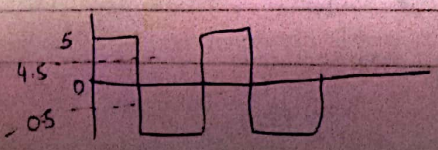
S_1 ——— 0 - 20 KHz ——— f_{c_1} 500 KHz ——— (500 - 520 KHz)

S_2 ——— f_{c_2} 525 KHz ——— (525 KHz - 545 KHz)

Problems of Analog Communication

→ Modulated signal combine with noise when demodulating the signal is not the original one.
(digital signal pe ni hota zyada)

→



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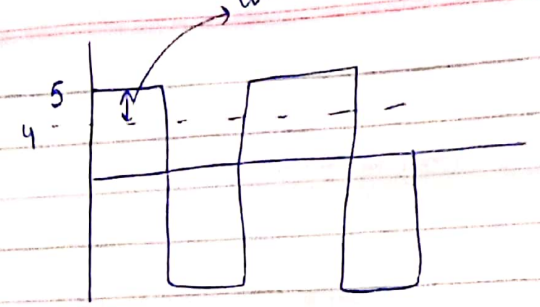


If digital data gets ensured then error recovery mechanism (check and detect)

Data Encryption

Digital signal can be recept and amplify it (amplifier)
this is digital regeneration

repeater/ does this regenerator

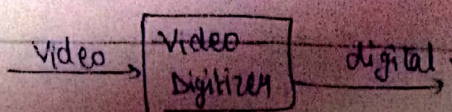
noise filter

Since digital data can be stored and processed we can do

Error Detection — CRC
Correction — Hamming Code (transmission me usually ni hota) detect kia & recover kia.
Recovery

Digital data can also be compressed & decompressed.
saving bandwidth

Video Digitization
↳ convert video into digital signal (video)



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Music → Audio Digitizer algo → Digital Music (.mp3)

↓

all music are .mp3 compressed

using Nyquest theorem

frequency ka signal sampling karo into 2-times through analog to digit converter

Music convert 20 KHz band width → Nyquest algo → (20000 Hz) double → 40,000 (sample) → converts it into 16 bit

↓

data rate nega 16 bit per sec

= 40000 X16

= 640000

640 kbps

There are 2 channels

= 1280 kbps

↓

yeh bhaut bandwidth lega

to compress ~~karega~~ karenga i.e using .mp3 compressor

4Khz → 64 kbps digital signal

yeh pass karenge

kw bandwidth ~~hai~~ lega

Video Compression

Video format

Suppose - 1024 × 768

↓ points in each line ↓ lines

Resolution → no. of pixels per frame

Scanned by CamScanner

We will get three analog signals for 1 pixel.
red, blue and green

Red decoded into 8 bit values will be 0-256
11 ray
for Blue & Green

code kme → 2^{24} colours can be displayed
1 pixel ko ~~color~~, ke lie 24 bits use hue

So ~~for~~ for 1024 x 768
= 1024 x 768 x 24 bits
will be required to
store the frame

Optical Illusion
↳ If Two frames come within a period.
Cannot be separated (indinguishable)
If two frames, does not come ~~within~~ within that
period can be separated

per second 50 frames generated
so each frame come within $\frac{1}{50}$ second

so they will be indinguishable due to persistence
of vision.

no ~~of~~ of frames per second
1024 x 768 x 24 x 50 bps

943718400 bps

921600 Kbps

9035 ~~Gbps~~ Mbps

Divide by 64 Kbps that many
channels of voice will be
required.

Scanned by CamScanner

Video ~~Compresse~~ Decompression

Compression
↳ If video is fast first frame is send, then diff of second & first frame is send and so on
~~bits~~

II^ly Decompression
First frame is received then second frame added and so on.

lossy Compression / loseless Compression
↓ ↓
Diff b/w sending & receiving picture (kuch distortion hoga signal ka) — No diff. in ~~compress~~ sending & receiving picture

Digital bandwidth expressed in bps, kbps, mbps

Video
↳ has variable bandwidth

Analog bandwidth in Hertz

digital data passed through a medium requires analog bandwidth
↓
bandwidth zyada then analog bandwidth bhi zyada milega.

Mobile voice me analog bandwidth nhi dia jata, zyada vo lossy compression hota hai isliè signal ~~d~~ loss hota hai

whereas
landline voice me compression ni hota

→ goes through space then also signal gets distorted bcoz of noise.

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Lightning does not affect the signal bcoz lightning sound frequency is very high.

But motor of industries generates high voltage spikes (containing all type of frequencies) if met with a signal to. Signal gets distorted.

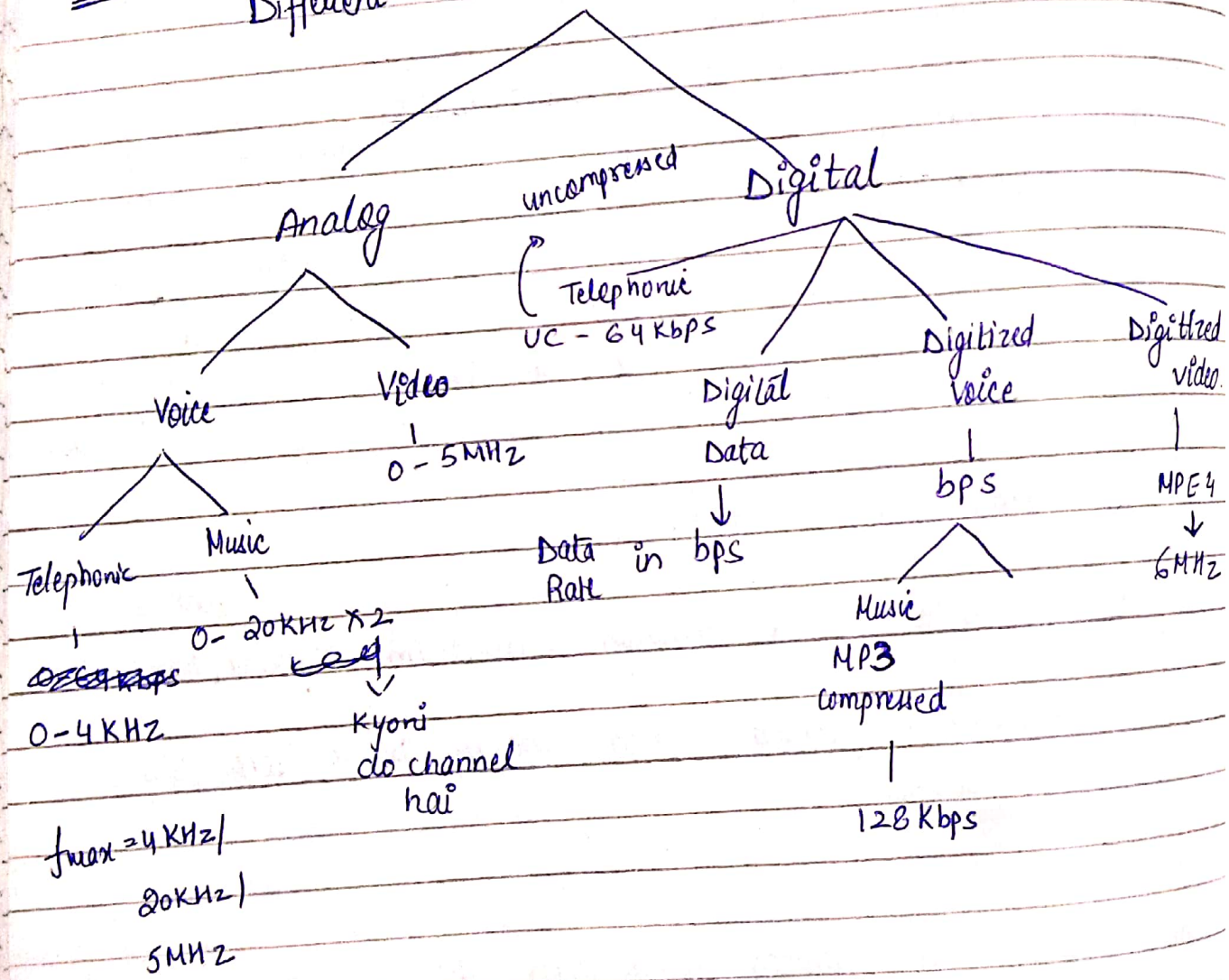
Scanned by CamScanner

Lightning does not affect ... sound frequency is very high.

But motor of industries generates high voltage spikes (containing all type of frequencies) if met with a signal to. Signal gets distorted

6/1/19.

Different Communication



f_{max} = 4KHz / 20KHz / 5MHz

Modulation done using f_{max}

$BW_s = f_{max} - f_{min}$

In analog telephonic

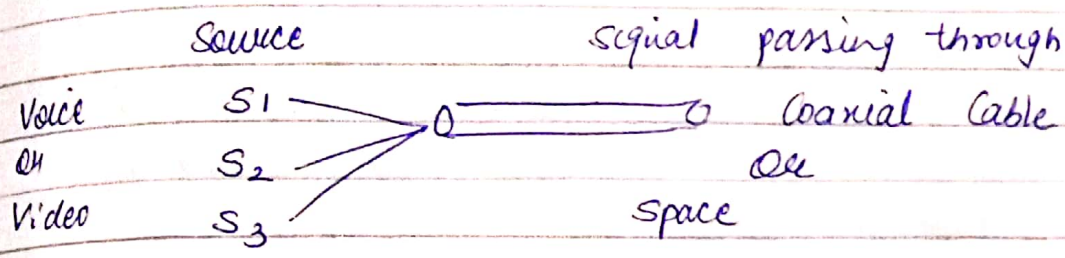
$BW_s = 4KHz - 0$

$= 4KHz$

Scanned by CamScanner

Transmit Data into space

low pass signal f_{max} = 0 - f_{max}



multiple sources sends signals together (Interference hoga) collision hoga.

Bandwidth of coaxial cable

and for space

0 – 40 GHz

~~frequency~~

40 GHz frequency signal is generated.

S_1 sends signals occupy 0 - f_{max}

S_2 0 - f_{max}

S_3 0 - f_{max}

(f_{max} (medium) frequency of medium)

all signals will occupy only this bandwidth rest will go waste.

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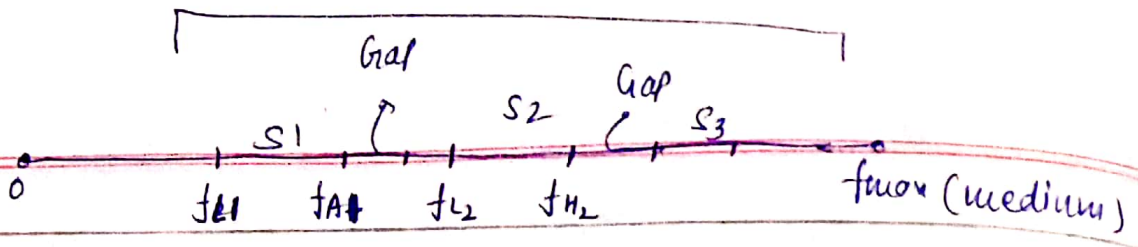
→ Modulation



Band mass signal

↳ non-zero low frequency and non-zero high frequency

Channel is low pass

but within it will be band pass with f_L and f_H

f_L ↓ low frequency

f_H ↓ high frequency

Composite signal → (Analog)

this is f_{max}

$s(t) = S \sin 2\pi f t$ (Bandwidth = 0 - f_{max})

→ [Modulation]

↑ Carrier Frequency

$c(t) = C \sin (2\pi f_c t + \phi_c)$

C ↓ Amplitude of carrier

f_c ↓ carrier frequency

ϕ_c → phase of carrier

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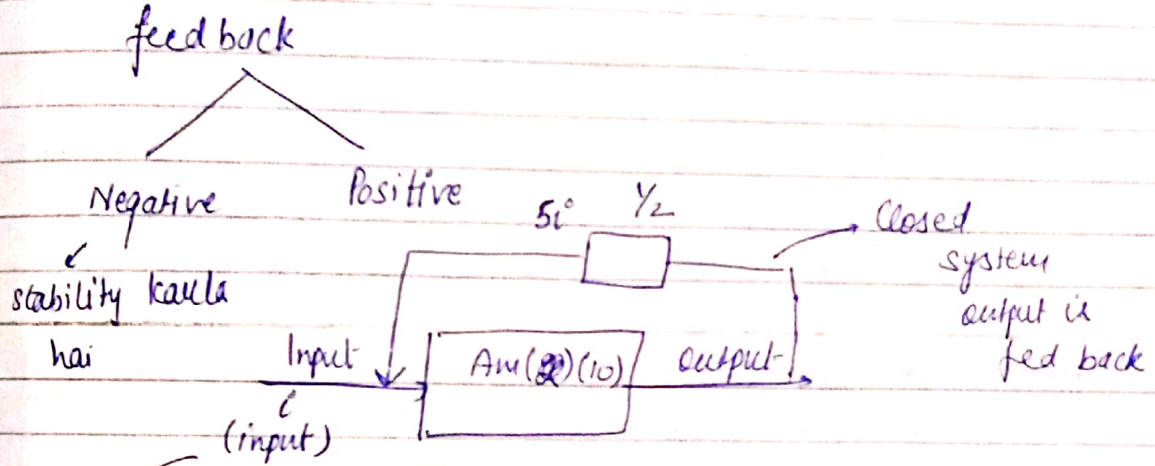
Noise is bad as signal
↳ but bcoz of this we are able to create oscillator and high frequency signal

Oscillator + feed back

Tuning frequency depend of Inductor & conductance in oscillator

Tuned frequency $f = \frac{1}{2\pi} \frac{1}{\sqrt{LC}}$



If input amplified → amplifier

If input decreased → decipitor

Amplitude effect = Amplification

→ If input is amplitude 10 times so 10 i
but when fed back is reduced by ½ so input is then 5i°

Negative feedback
↳ is good bcoz the input signal which was increased by the amplifier due to the negative feedback the signal is reduced.

output signal is subtracted by a factor - that is said to be negative feedback.

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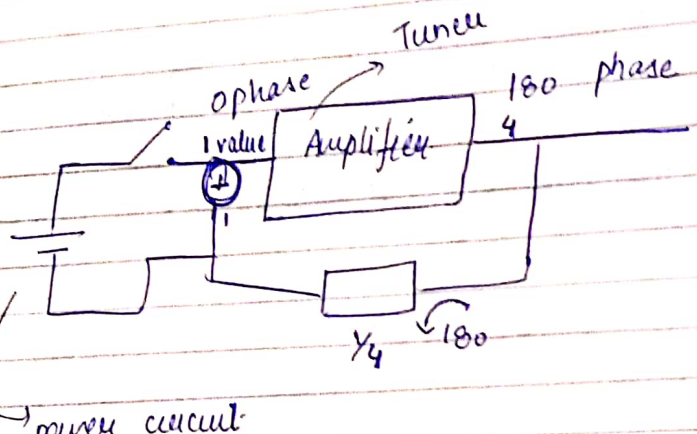
Positive feedback

Input dia amplify hua + positive feedback add hua to input signal bd jaega

ie positive feedback



When o generates

~~frequency~~ noise ⊗ (containing all frequency)

~~Noise will vanish~~

Tuner will pick any one frequency and then amplified and noise vanish

source ~~se~~ gayab ho jaega

$$f = \frac{1}{2\pi}\frac{1}{\sqrt{LC}}$$

→ chang this C

So it will be

$$f_{C_1} = \frac{1}{2\pi}\frac{1}{\sqrt{LC_1}}$$

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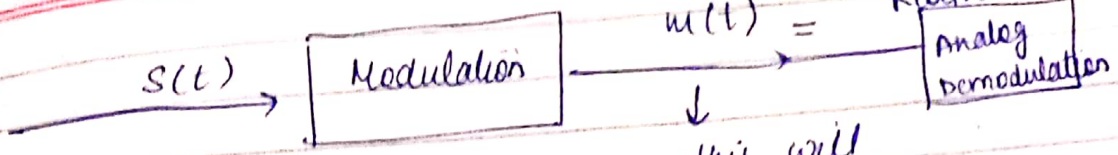


this will have

$f_L - f_H$

$BW = f_H - f_L$

all depend upon modulation technique

f_L depend on carrier frequency

$f_L = f(f_c)$

(function of carrier frequency)

BW depends upon f_{max}

In Amplitude modulation

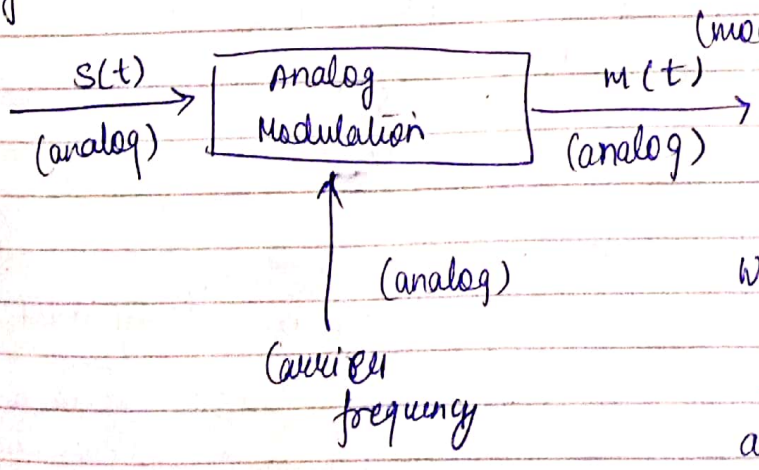
(lower frequ) (higher)

$f_c \longrightarrow f_c + f_m$

f_L f_H

depends upon carrier & original signal

Analog Communication



When all signals are analog then it is analog communication

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Amplitude Modulation

Carrier frequency f_c, ϕ_c are fixed

Amplitude C will vary

$$C_{man}^{(t)} = C + K_a \, s(t)$$

- C → amplitude varied
- K_a → constant of amplitude modulation; depend on depth of modulation (kitna power input kar rhe ho)
- $s(t)$ → proportional to the instaneously value of the signal

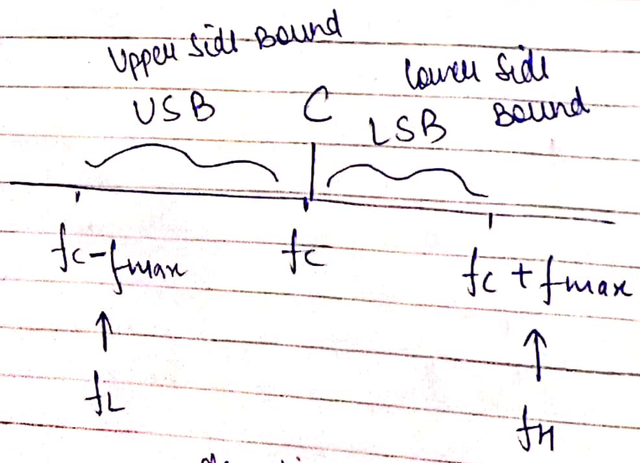
$$m(t)_a = \left(C + K_a S \sin 2\pi f_{man} t\right) \sin\left(2\pi f_c t + \phi_c\right)$$

$\phi_c = 0$ when amplitude modulating

$$m(t)_a = \left(C + K_a S \sin 2\pi f_{man} t\right) \sin\left(2\pi f_c\right)$$

↓

3 frequencies ayengi m(t) me

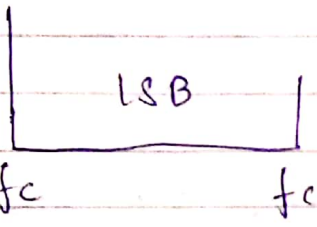


] All will have certain amplitudes depending on carrier & original frequency

m(t) Bandwidth

$$BW = f_H - f_L$$
$$= 2 f_{max}$$

In m(t) we are sending



so $BW = f_{max}$

2 Frequency Modulation

C, ϕ_c → constant

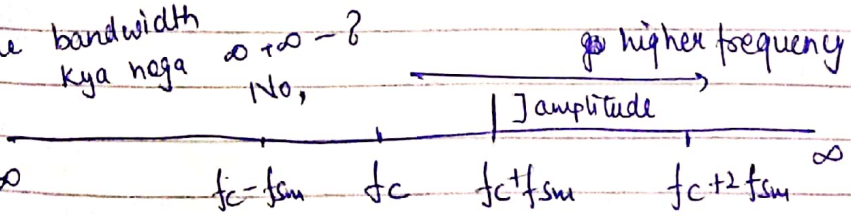
f_{cm} (Modulated carrier frequency)

$$f_{cm}(t) = f_c + K_f s(t)$$

$$m(t) = C\left(\sin 2\pi \left(f_c + K_f S \sin 2\pi f_{max} t\right) t\right)$$

↳ this will have many frequencies

Bo isme bandwidth kya hoga ∞ +∞ − ? No,



amplitude km hoga inversely proportional to N^{th} frequency

frequency with opposite phase

Ky

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Actual Bandwidth = ∞

Effective Bandwidth

BWe u/L = $n f_{max}$

Sideband

if take upper band + lower band.

BWe = $2n f_{max}$

FM audio quality is very high

↓

costly w.r.t to bandwidth

Video is 5MHz when FM then if n=5

bandwidth will become 25MHz

AM is not costly w.r.t to bandwidth

Stereo – 20kHz × 5 = 100 KHz Bandwidth

2 channel hai

= 100 × 2KHz

= 200 KHz

3 Phase Modulation

C, f_c → constant

$\phi_{cm}(t) = \phi_c + k_p s(t)$

Not used.

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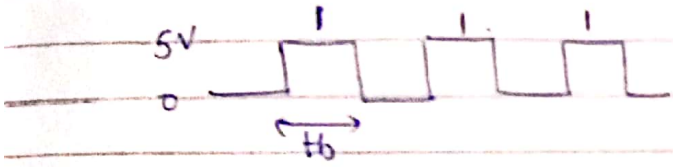
proportional

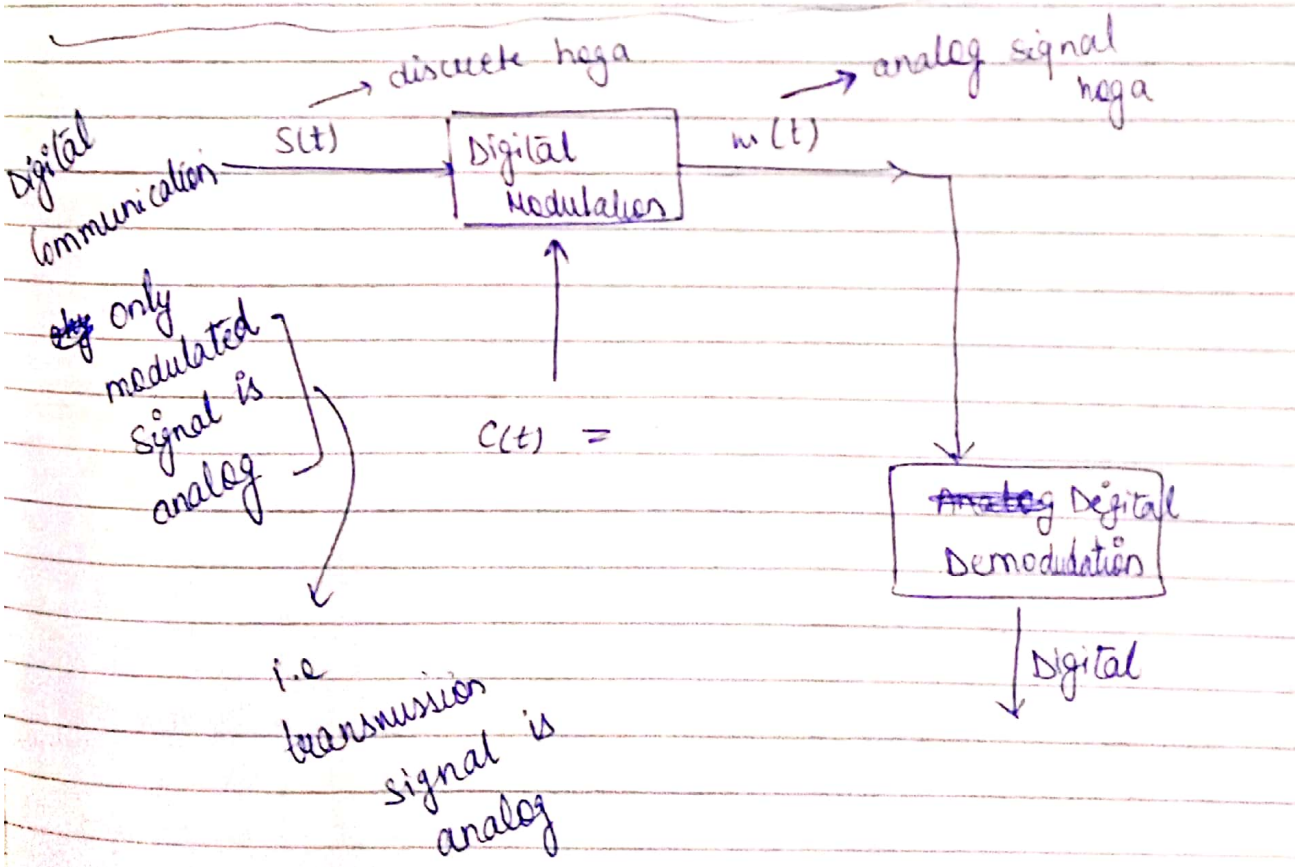
bps ∝ baud rate
of transmission

S(t) = 5V

Digital → Digital Data (original)
Digitized music
Digitized video



S(t) = 5V 0 ≤ t



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Amplitude Shift- Keying — C varies f_c, ϕ_c → constant

Frequency Shift- Keying — f_c varies C, ϕ_c → constant

Phase Shift- keying

Scanned by CamScanner

Amplitude Shift- Keying — C varies, f_c, ϕ_c → constant

Frequency Shift- Keying — f_c varies, C, ϕ_c → constant

Phase Shift- keying

8/2/19.

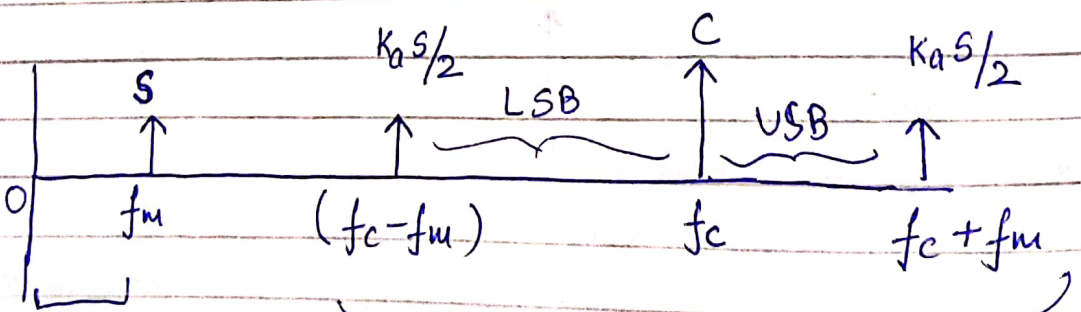
~~$u(t)_a = A(C+$~~

$u(t)_a = (C + K_a S \sin 2\pi f_m t) \sin 2\pi f_c t$

$= C \sin 2\pi f_c t + K_a S \sin \underbrace{2\pi f_m t}_{B} \sin \underbrace{2\pi f_c t}_{A}$

$= C \sin 2\pi f_c t + \frac{K_a S}{2} \cdot 2 \sin B \sin A$

$= C \sin 2\pi f_c t + K_a S \left(\cos 2\pi (f_c - f_m) t - \cos 2\pi (f_c + f_m) t \right)$



signal original Bandwidth.

modulated wave me three frequency aa gya

BW_S after modulation $= f_c + f_m - f_c + f_m = 2 f_m$

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Original BW's $= f_m - 0 = f_m$

LSB me we have carrier & signal

hum hta denge

So we have USB

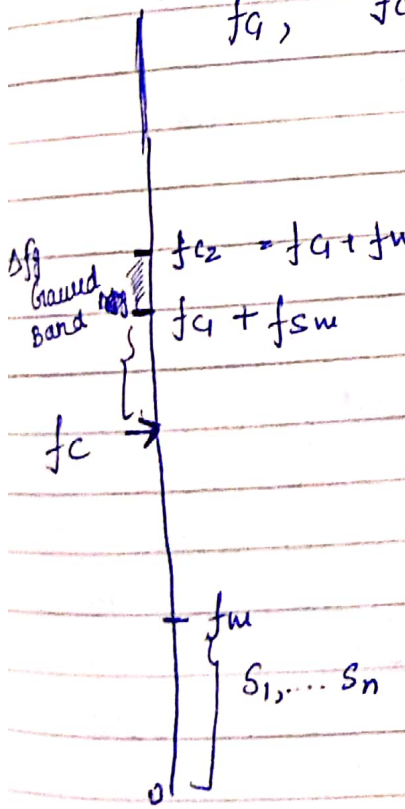
$BW(m)_e = f_m + f_c - f_c$

$= f_m$

We have many sources

$S_1, S_2, \ldots\ldots\ldots S_n$

$f_{c_1}, f_{c_2}, \ldots\ldots\ldots, f_{c_n}$



if oscillator ka frequency km ho gya to wo interfere karega is lie there is a gap known as guard band.

$f_{cn} = f_{cn-1} + f_m + \Delta f_g$

$f_{cn} < f_{cn}$ # off (median)

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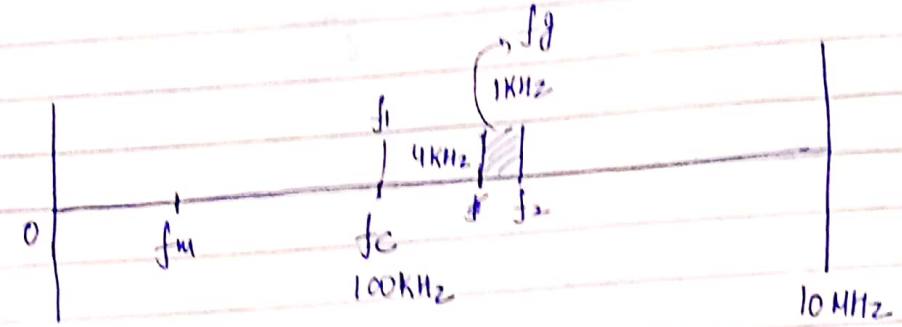
12/2/19

Quality ke lie frequency modulation
Voice ke lie amplitude frequency



$f_m = 4KHz$

guard band $f_g = 1KHz$

$= 10 \times 10^3 - 100$ → frequency (here it can be 20KHz)

$4n + n - 1$

$= 5n - 1$

$= 5n$

$(10000 - 100) = \frac{9900}{5} = n$ (no. of channels)

FM

Stereo Music - $20KHz \times 2 + 1KHz$

$= 41 KHz$

$\approx 40 KHz$

$$m(t)_f = C(\sin 2\pi (f_c + k_f 5 \sin 2\pi f_m t)t)$$

there is a sin within a sin
can be breaked using high

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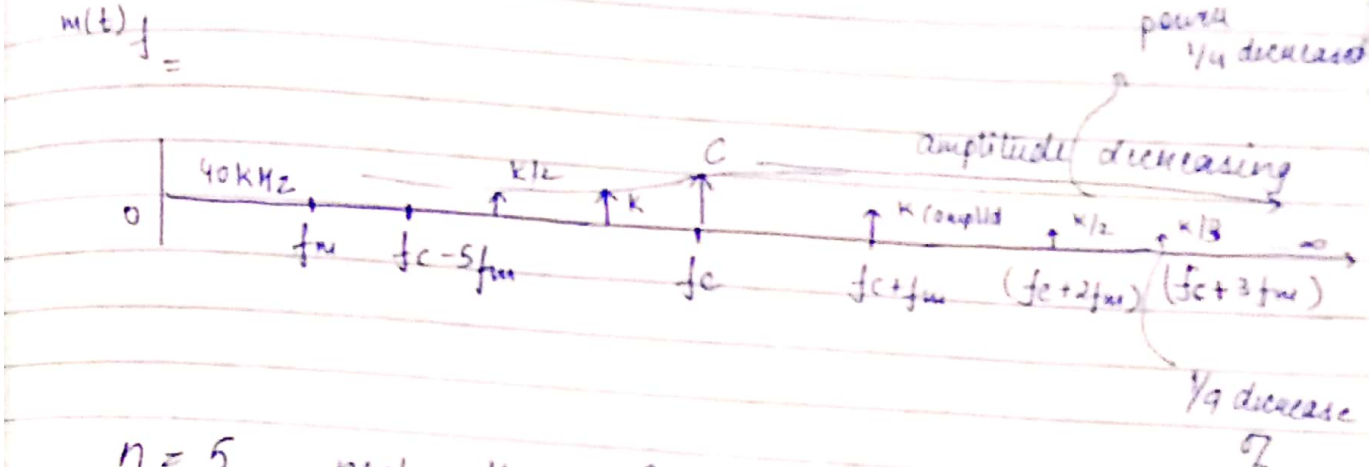
m(t) f =



n = 5 next after this power will not be considered.

we will stop at $f_c + 5f_m$

2 approximation

1.) ∞ bandwidth tha use kar kia 10 f_m

2.) then we took lower and upper side band.

$BW_C(e) = 5f_m$

BM music Channel e = 20 × 5
= 100 KHz

Amplitude ~~mein~~ modulation me demodulation me noise ata hai

Frequency modulation me demodulation me noise ni ata → quality achi ati hai

→ Telephonic voice

Given BW → 100 KHz − 5MHz

Music channel → 20KHz × 5
= 100 KHz

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90 MHz

FM channel = 100 KHz
= 0.1 MHz

$$\frac{108 - 90}{\text{Bandwidth}} = n \times (0.1) + (n-1)(.01)$$

(frequency of 1 channel; frequency of guard band (10 KHz))

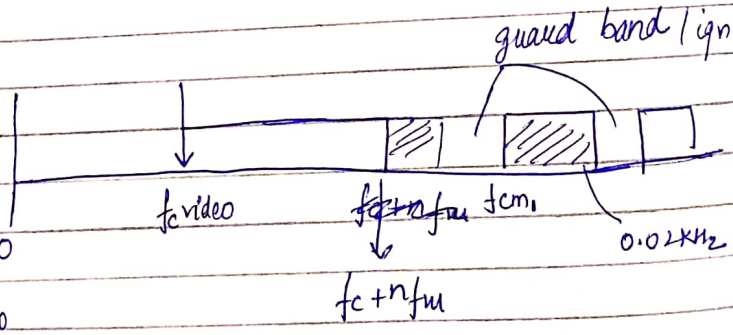
This is frequency division multiplexing

13/2/19

Stereo music transferred through FM

$n_2 = 1$ for AM

$n_2 = 5$ for FM



① A+V ⇒ AM (Audio, Video)

$5\,MHz + 0.02\,MHz + 0.02\,MHz = 5.04\,MHz$

Music ko AM kia to quality ni ayega to yeh kaunga hi nhi

2) A +

Yeh

pr

3. A (FM) + V (

0.2 MHz is

FM for audio.

Hence TV ka bandw

In TV transmis

Q4

Q. Why do we do

Whem source is d
analog and
This is know

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in FM

20 KHz x 5
+
20 KHz x 5

2.) A + V ⇒ FM

25 MHz + 0.2 MHz
= 25.2 MHz
(huge bandwidth as compared to AM)

frequency of guard band (10 KHz) .01

Yeh bhi disregard kaunge, but audio ko FM kaunge pr video ko AM kaunge

3. A (FM) + V (AM) = 0.2 MHz + 5 MHz
= 5.2 MHz.

0.2 MHz is very less so we can afford FM for audio.

Hence TV ka bandwidth km ho gya.

Q In TV transmission which modulation technique is used.

OR

Q. Why we do FM for audio.

Ans

When source is digital medium transmission is analog and destination is digital
This is known as digital communication.

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(source, medium and destination me analog)

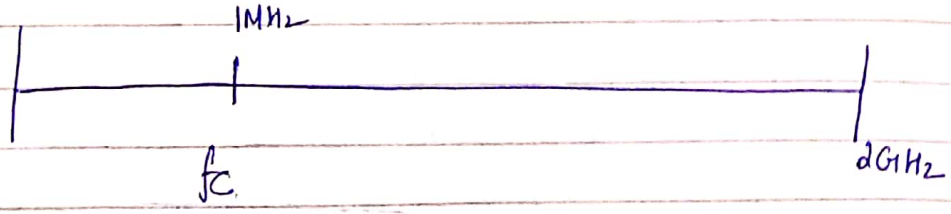
1.) Fully analog communication

→ space

→ wired medium (cable)
(coaxiable cable)
Cable TV

Coaxial Cable

Cable Bandwidth



Total Bandwidth = 2GHz − 1 MHz

= 1999 MHz

* 1 Channel take 5.2 MHz

1 GHz = guard band

$$1999 = (5.2)n + (n-1)(0.1)$$

$$n = \left\lfloor \frac{1999}{\quad} \right\rfloor$$

Twisted Pair

↳ Telephonic line no modulation done

0 — 4KHz

Pulse Code Modulation se 64Kbps analog digital ban jata hai

then this reversed onto analog using reverse pulse code modulation.

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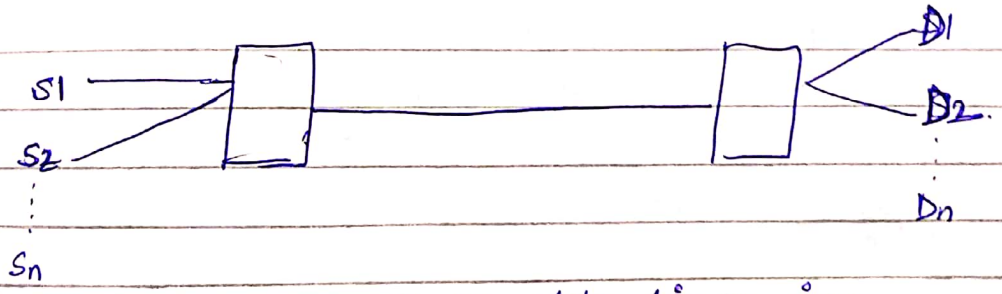
Digital communication — not fully digital communication (source and destination digital, medium analog)

— On wired medium
- twisted pair — 0 — 1 GHz
- coaxial cable — 0 — 2 GHz
- optic fibre — 0 — 20 GHz

Single cable & a single source
no problem.
But when multiple sources
then min ho jaega
using time division multiplexing
or
Synchronous TDM

& STDM.



t=0 pe S1 ka data line pe jaega
then after ΔT S2 ka data
and till Sn.
If some source has no data then dummy data is send
and at receiving end after some time signal demodulated i.e ~~given to source S1, ... Sn.~~
S1, S2, ... Sn given at destination D1, D2, ..., Dn

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Analog me wire me FDM hoga. eg. Cable TV

Digital me wire me TDM hoga.

Fully digital ← On space ← Wired me source, destination and medium bhi digital hoga

Fully digital me digital regeneration

Source & Destination pe processing hoga

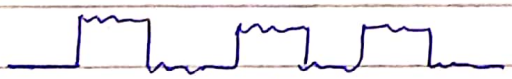
error detection / recovery

compression decompression

and many more

during medium

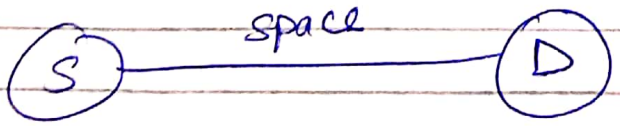
noise can come



bt noise hta ke

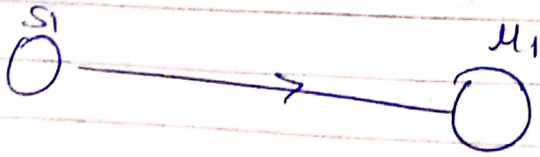
we can amplify

— On space



digital digital

if single source & receiver



then digital data can be send

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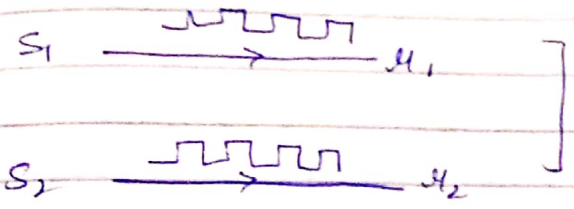
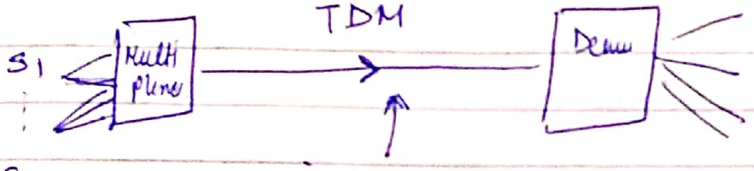
But when multiple sources



but both digital mix ho jaega interference hoga.



wired tha

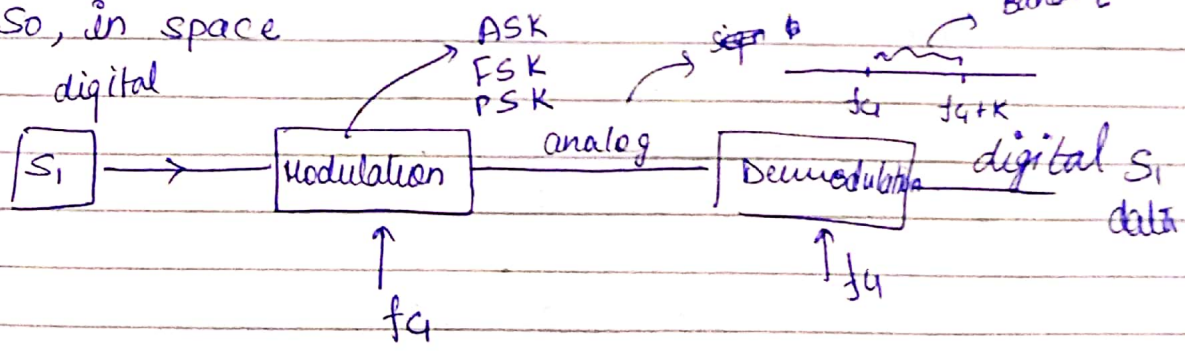
but space is vast

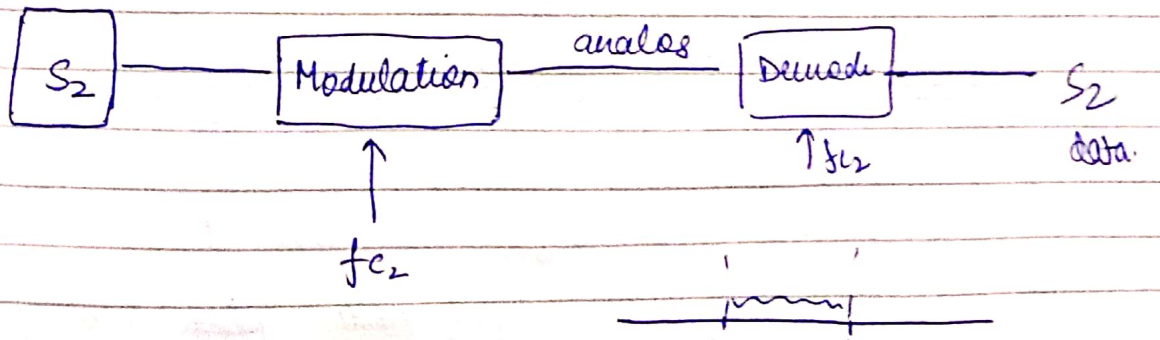
anyone can mix malicious ~~code~~ data.

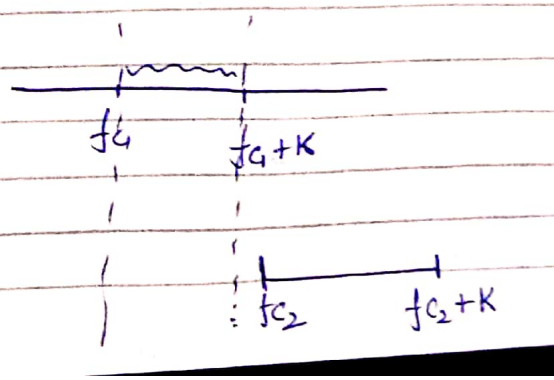
Hence, direct digital comm. is not possible in space.

Hence digital data is not sent through space.

So, in space digital







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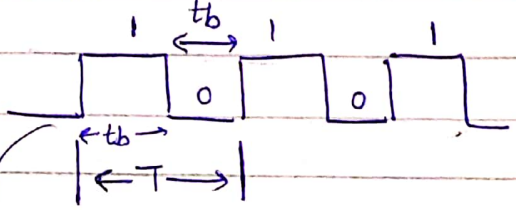
This is hybrid communication
not fully digital, not fully analog

during transmission signal regenerate nhi ho paega. bcoz analog. hai during medium.
but error detection / recovery at source and destination can be done.

→ this data is changed maximally to ike lie bandwidth bhi zyada hoga.

1 1 0 1 0



bit time is controlled using digital clock

Data Rate
t_b sec time me 1 bit is send
1 sec = $\frac{1 \text{ bit}}{t_b}$

BRT → bit rate transmission
= digital rate of transmission
= digital BW = $\frac{1}{t_b}$

$t_b \downarrow$ to BW ↑
agar ~~jldi~~ ~~jldi~~ jldi jldi bhejoge to medium change zyada hoga.

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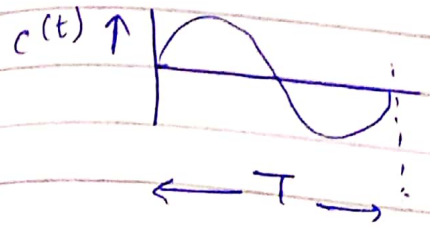
2.) Signalling Element

(We will use carrier to send digital data)

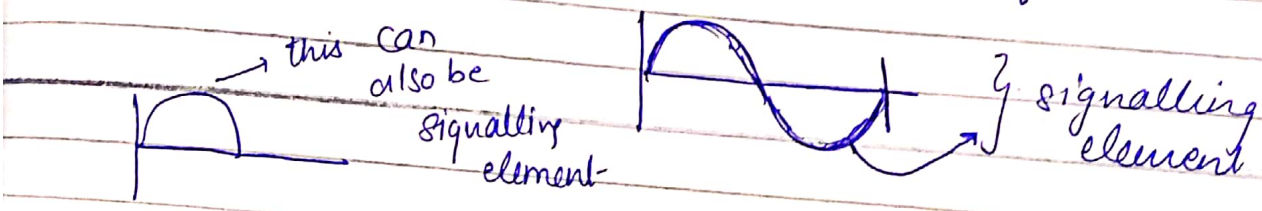


Carrier signal

$$fc = \frac{1}{Tc}$$

but digital signal is discontinuous and carrier signal is continuous

We will transfer 1 bit on 1 cycle of carrier



In ASK.

if bit is 0

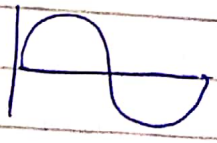
so signal $s(t) = 0$

Amplitude of Carrier

$$m(t) = C + K_a \times 0$$

So sending 0 the amplitude not change

So for 0



but 1

So $m(t) = C + K_a \times 5V$

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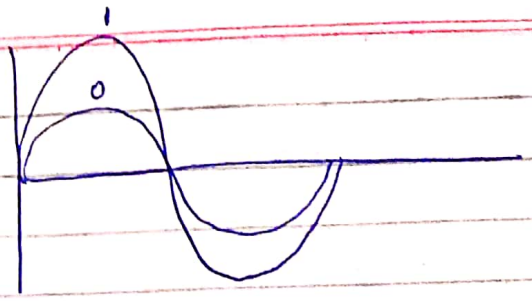
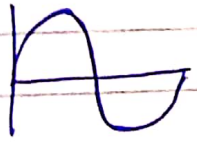
1 signalling element
= 1 Baud



3) Signalling rate = Baud Rate
No. of signals transmitted per rate
= f_c

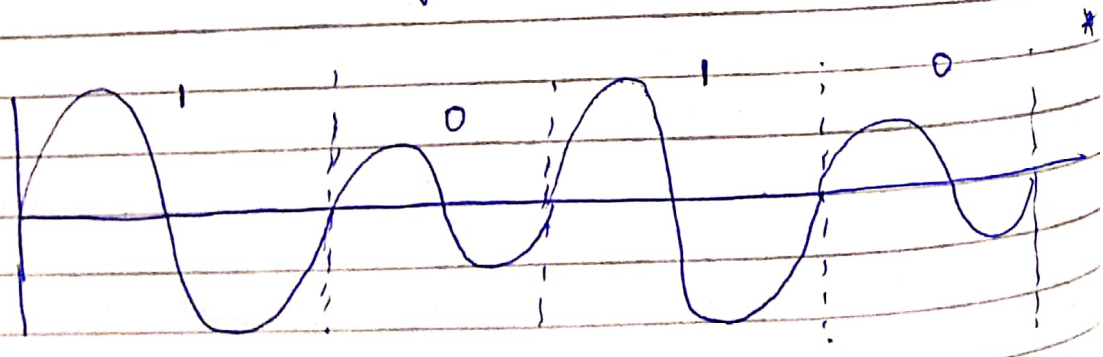


~~Eg~~. No. of signal = f_c

But if 

So, no. of signals = $2f_c$

ASK sending 101010



1 signalling element me 1 bit

2 level of signalling hunge to bit rate = baud rate.

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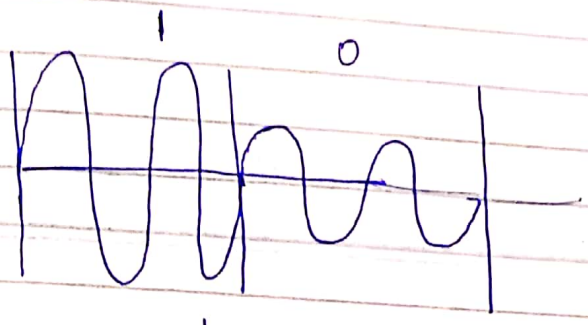
Carrier ka ek frequency
So Bandwidth is 0.

Simple ASK — 2 level of signalling
(i.e using 2 level we can send digital data)

* This is a composite analog signal containing different frequencies.
and since not single wave so bandwidth is not 0.

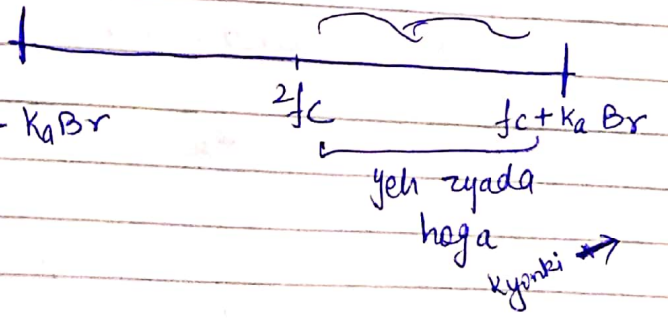
Baud rate is doubled.

So

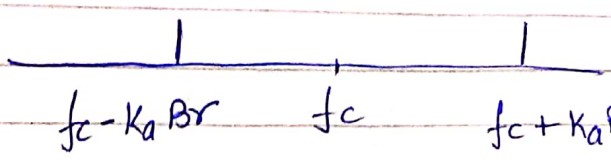


→ signalling rate = 2fc

↓
→ yha pe change faster hoga



→ signalling rate = fc →



$BW_{CH} = 2 K_a B_r$

We need to choose Ka
we choose 0 then $BW_{CH} = 0$ then no

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information is send

When $K_a = 1$

Bandwidth = 2 Baud Rate

This is very high

So, value of K_a (optimal)

$$K_{a_{op}} = \frac{1}{2}$$

So, in ASK

$$\boxed{BW_{CH} = B_r}$$

information can be modulated / demodulated easily

b_r = bit rate

BR_μ = Baud Rate

BW = Bandwidth

$BR_\mu = BW$ when $K_a = 1/2$

when 2 level of signalling then

$b_r = BW$

↓

Also known as digital bit rate.

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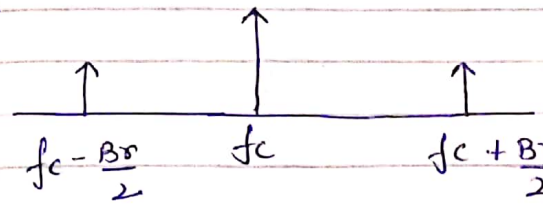
15/2/19

ASK



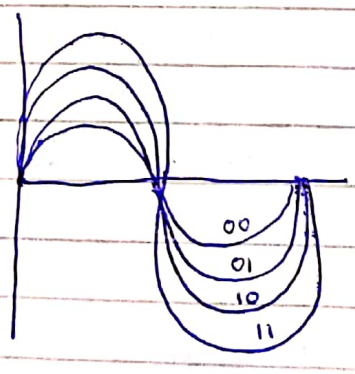
$$BW_{CH} = Br = fc + \frac{Br}{2} - fc - \frac{Br}{2}$$

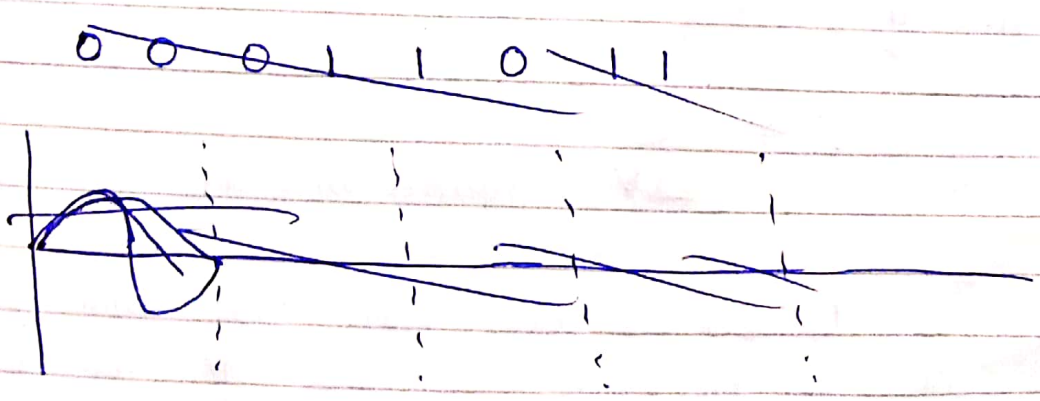
Digital transmission ∝ Analog Bandwidth of the channel

4 level of signalling

2 bits will be choosed for signalling element

1 baud me 2 bits send kar sake hai





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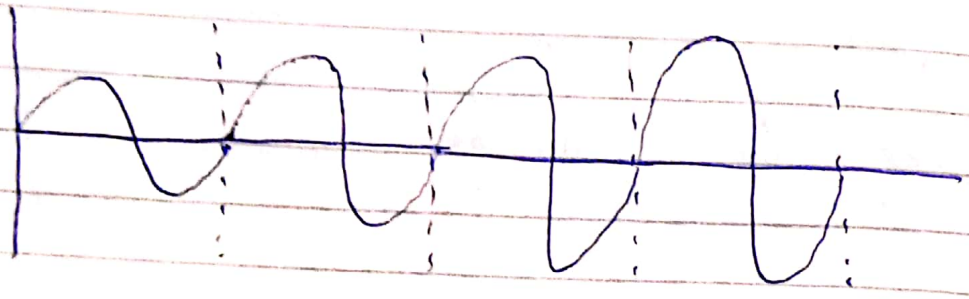
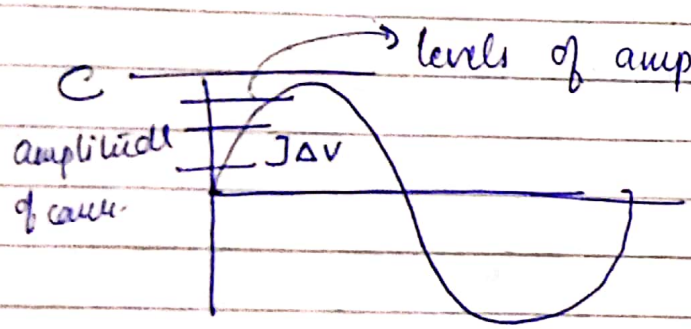
00 01 1 0 11



$b_r = B_r \times \log_2 V$

$= BW \times \log_2 (V)$ → we will change this

Jitni analog bandwidth utna baud rate.
So, we need to minimise bandwidth and increase the bit rate transmission.



levels of amplitude of carrier can be used to transfer ~~different~~ no. of bits.

C ko kitne level tk divide karenge - ?
V → no. of levels

$$V = \frac{C}{\Delta V \text{ (difference b/w two levels)}}$$

If ΔV is very less then there are chances of noise because if two levels are very near to so, if noise comes then it will not be easy

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to distinguish b/w upper level or lower level.
it is 00 or 01
it will be difficult to distinguish.

In noisy environment, ΔV has to be kept greater.

ΔV_{min} = function of noise level
~~or signal rate~~
Noise

$$\propto \frac{1}{\frac{\text{Signal}}{\text{Noise}}} = \frac{\text{Noise}}{\text{Signal}}$$

$$\Delta V_{min} \propto \frac{\text{Noise}}{\text{Signal}}$$

$Noise_{max}$ ↑ to ΔV_{max} ↑ hoga

So $V_{min} = \frac{C}{\Delta V}$

$V_{minimum}$ hoga

Modem capacity depends on
1-) Noisy Environment (Noisy)

Q But we cannot increase the amplitude of the carrier signal —?

Ans.

$P_{modem} \propto C^2$

C increases
P → max (C^2)

$P = V \times I$ = increases
250 V

Current I increase

$I^2 \times R$ → Power burnt in coil increase

current increase ho rha hai to resistance decrease karna padega

$R = \rho \frac{L}{A}$ (L → constant)

to Area increase karna padega

i.e wire will be thick so the price of modem is increases.

So, for a particular modem amplitude of carrier will be fixed and so the level.

Q

$f_c = 4KH_z$

$B_r = 4000$ ~~Bud~~ Baud / sec

$V = 16$

$b_r = 4000 \times \log_2 16$

$= 4000 \times 4$

$b_r = 16000$ ~~kb~~ bps

$= 16$ Kbps

$= \boxed{B_r = 4000 = 4KH_z}$

$BW = 4 KH_z$

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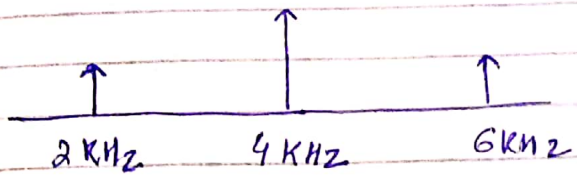
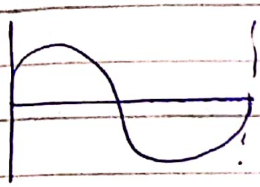
Frequency Spectrum



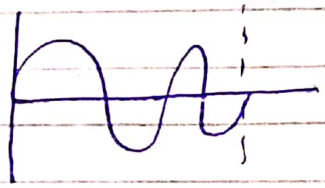
Frequency Shift Keying (FSK)

V no. of frequencies

If two frequencies taken



for 0



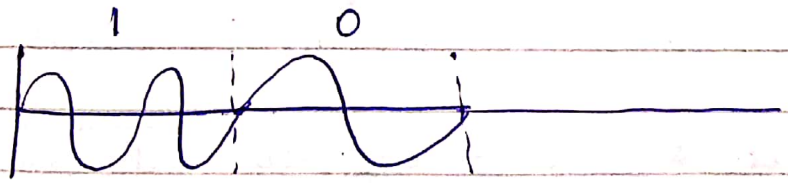
for 1

(frequency increased)

So

$f_L = f_c$ and $f_H = 2f_c$

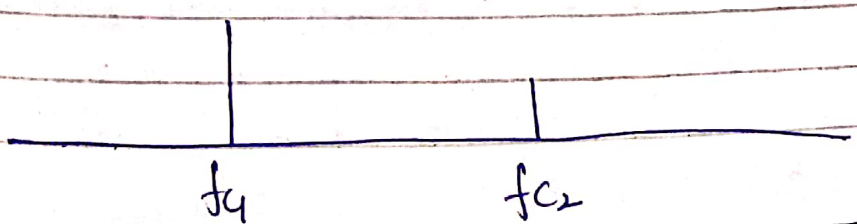
f_{c1}, f_{c2} are two frequencies



$2f_c$ f_c

not a pure signal (a composite signal)

$f_{c2} = f_{c1}$



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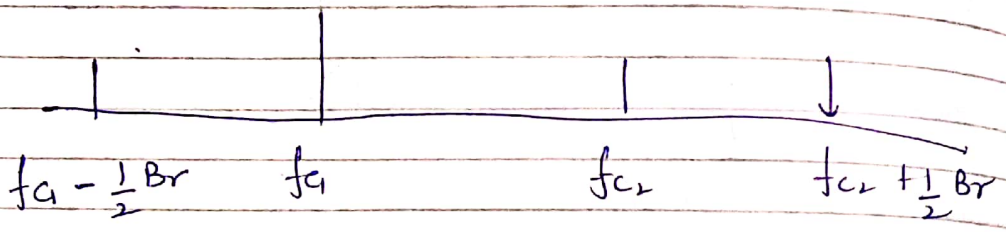
$f_{c_1} = f_c$

$f_{c_2} = 2f_c$

f_{c_1} will be changed to f_{c_2} & f_{c_2} to f_{c_1} so that will generate two more frequencies proportional to baud rate

So FSK is no



$$BW = f_{c_2} + \frac{1}{2}Br - f_{c_1} + \frac{1}{2}Br$$

$$= (f_{c_2} - f_{c_1}) + B_r$$

$$B_r = BW - (f_{c_2} - f_{c_1})$$

$$= BW - (2f_c - f_c)$$

$$B_r = BW - f_c$$ (yeh to 2 level)

level & = 3 bits are sent per signal.

$$b_r = \left(BW - (f_H - f_L)\right) \log_2 V$$

V ↑ to frequency bhi bhadegi

f_H & f_L ka gap bd jaega

So V will not be increased

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fc

So FSK is not chosen for digit data.

to

Rough
OOK

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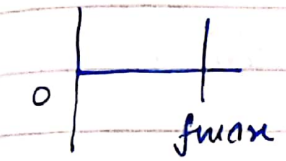
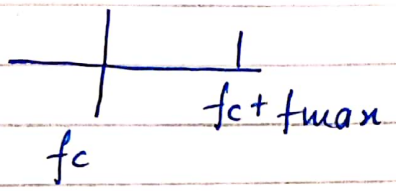
So FSK is not chosen for digit data.

20/2/19

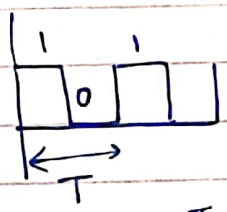
Analog signal ka bandwidth



After modulation, channel bandwidth

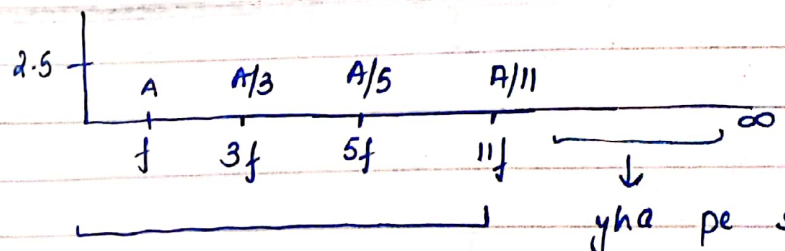


But digital signal



T = Time period of square wave

Digital signal is a no. of sine wave



yha pe signal ka strength km ho jaega uska significance nhi rahega

So spectrum ka ban gya from 0 – 11f

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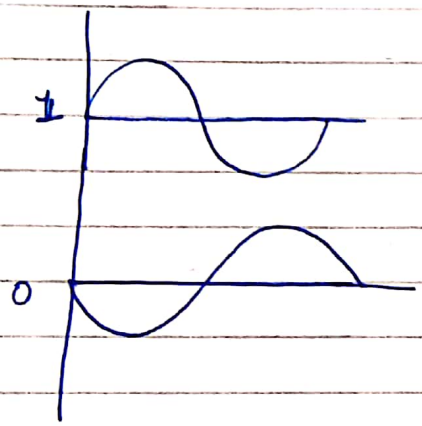
$BW_S = 11f - 0 = 11f = \frac{11}{T}$

FSK

$BW_{CH} = (f_{CH} - f_{CL}) + B_r$

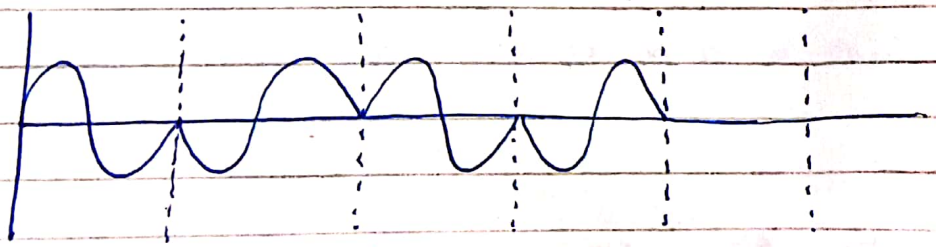
Q Why FSK is not used for digital data?

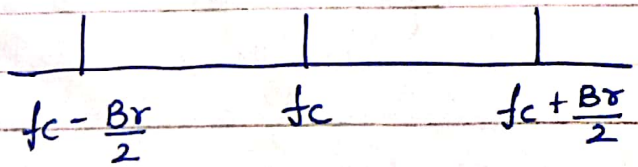
PSK → Phase shift Keying



sign signal changes at the change of baud rate so, not a sin wave

1 0 1 0 1 0





$BW_{CH} = B_r$

How to increase baud rate?

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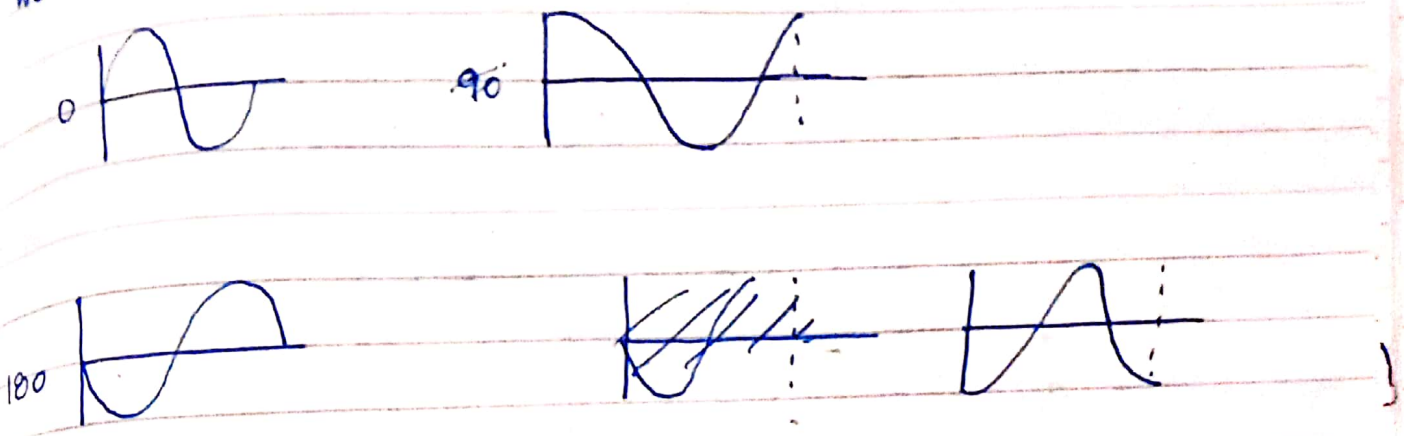
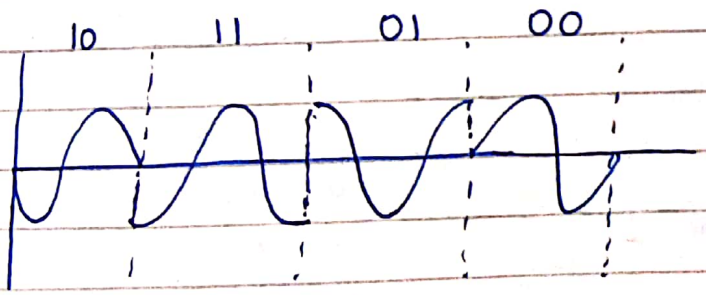
We take 4 phases



00 → phase 0
01 → phase 90°
10 → phase 180°
11 → phase 270°

When sending 2 bits per baud

10 11 01 00



Baud rate kmi kia to pattern jldi change hoga

Baud rate zyada kia to pattern slowly change hoga. -?

$d_M = B_r \times \log_2 4$

$BW \times 2$

Phase since not related to power. So we increase V much more than ASK.

0, 45, 90, ... 270

8 phase 3 bits can be send.

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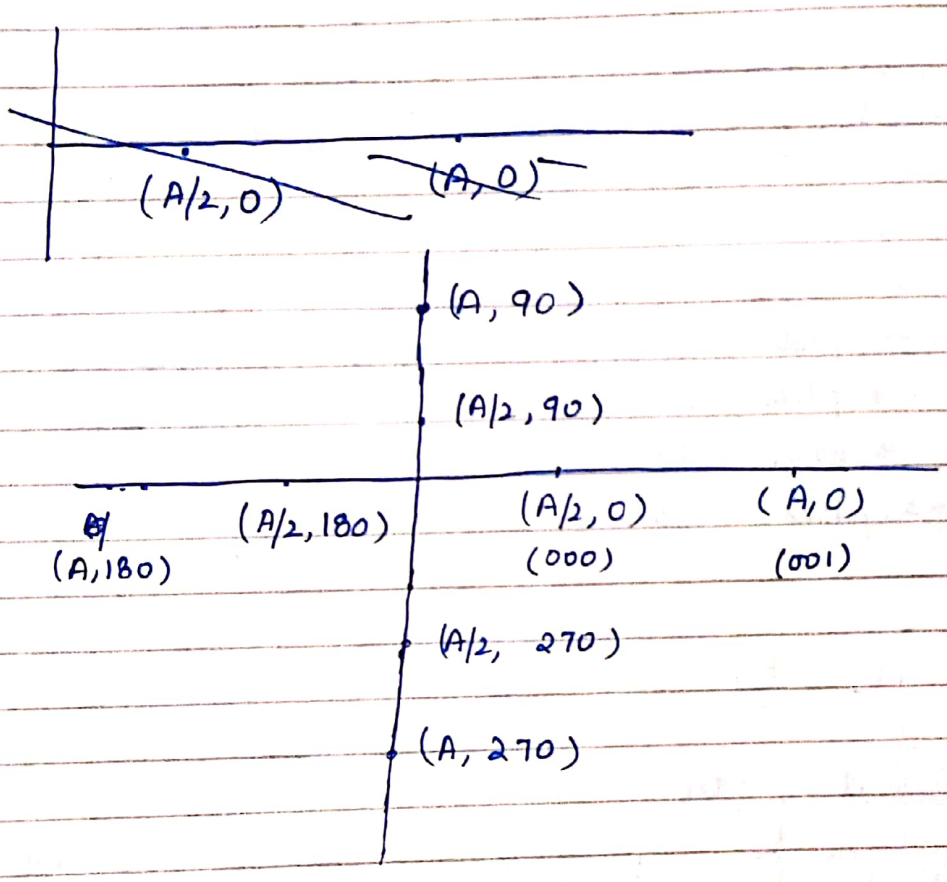
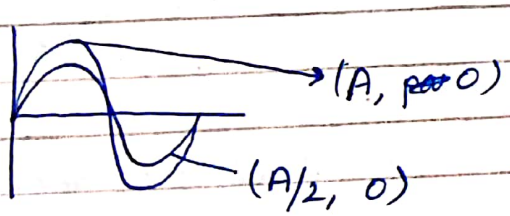
ASK as compared to PSK
ASK is also discarded.





Amplitude me 8 levels

Phase me 32 level

$V = 2^3 \times 2^5$ levels aa jaenge

This is the quadrature amplitude modulation (QAM)

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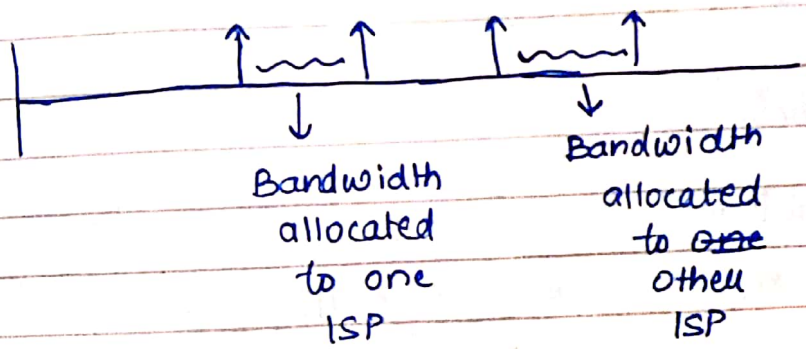
Multiple Access Schemes

wireless communication to provide services

- Radio
- TV
- Mobile
- Wifi

ISP provide these services and they should get bandwidth in space depending upon the service



Frequency Division Multiplexing is used to divide bandwidth

Mobile Communication ke lie

1800 – 1900 MHz

890 – 960 MHz allocate hota hai

For Wifi

2.04 GHz –

5 GHz –

These zones are license-free

Scanned by CamScanner

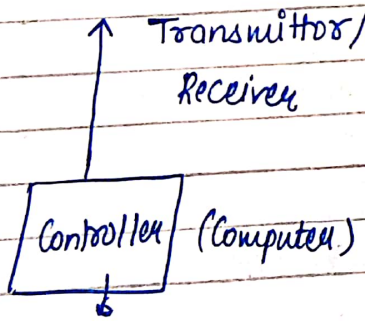
Multiple Access Schemes divided into

→ Centralised
(central coordinator who will create and allocate channel to user i.e mobile device)

Distributed
(used for wifi)
(no centralised coordinator)
(laptop, smart-phone)
(Based on the protocol channel will be allocated)

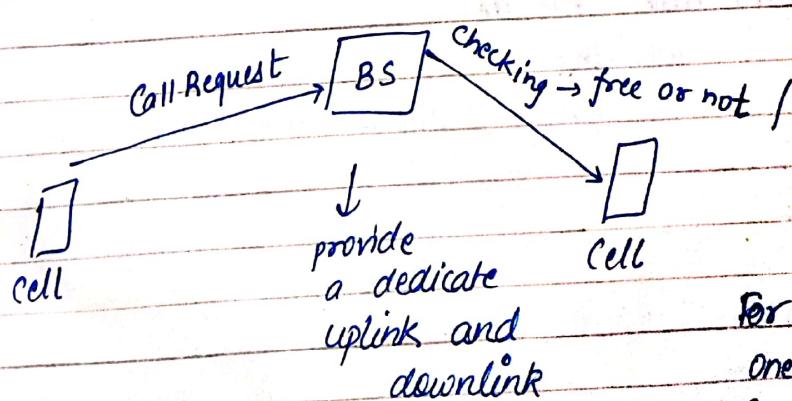
e.g Mobile Communication
= Base Station
For mobile voice/data communication

BS ka two parts



(Serve a particular area (radius))

There will be multiple stations



For voice one link can be provided one will say and other listen.

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For data
we require 2 link
one for sending, one for receiving

Centralised

FDMA TDMA CDMA (for mobile communication)

Antenna for both transmitting / receiving known as trans - receiving antenna.

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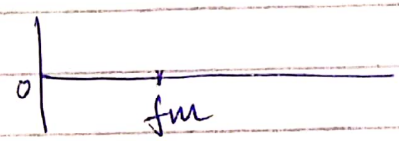
For data
we require 2 link
one for sending, one for receiving

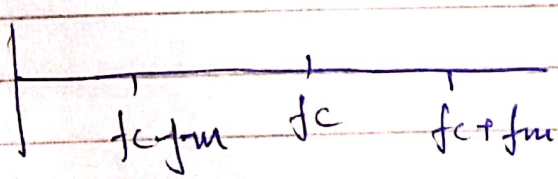
Centralised (for mobile communication)
- FDMA
- TDMA
- CDMA

Antenna for both transmitting / receiving known as trans - receiving antenna.

23/2/19



Frequency spectrum of → original signal
→ modulated signal



$BW_{CH(a)}$ = Bandwidth of the channel in amplitude modulation.

If we include LSB + USB
then bandwidth is doubled.
But, taking one band helps ~~demode~~ separate original signal from carrier at receiver.

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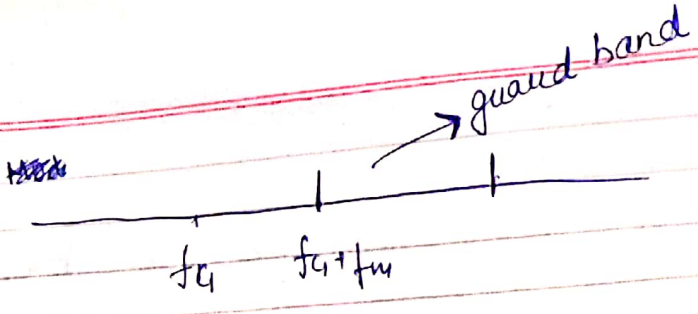
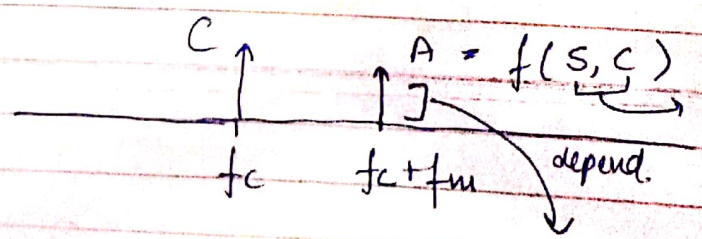


Next frequency $f_{c_2} \geq f_{c_1} + f_m + \Delta f_g$

$f_g \rightarrow$ ek frequency denote karta hai bt since guard band is not a single frequency so Δf_g.

Carrier frequency is generated by oscillator.
So, frequency kmi zyada hoga to interfere hoga.
So, guard band rkhte

In frequency modulation
we have a sine wave within a sin wave. we cannot separate it using trigonometric functions.



depend kaunsa
- Signal power, Carrier power] → depend on the depth of modulation
- K_f → frequency modulator pe depend kaunsa

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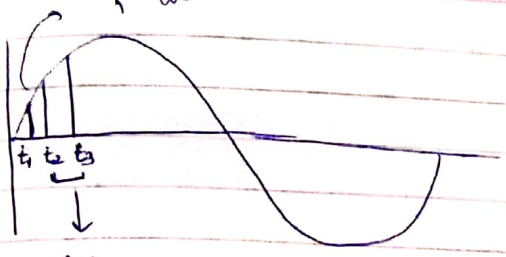
0 dena to 0000 0000
1 dena to 0000 0001



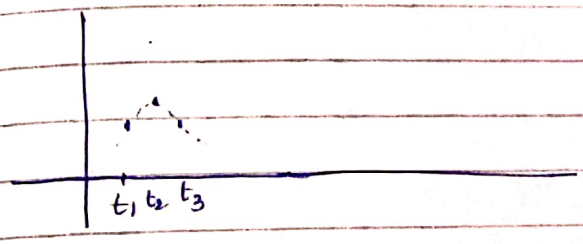
gap jitna km hoga utna digitization acha hoga

ADC
Analog
Digital
Convertor
using 8 bit

① Sampling.

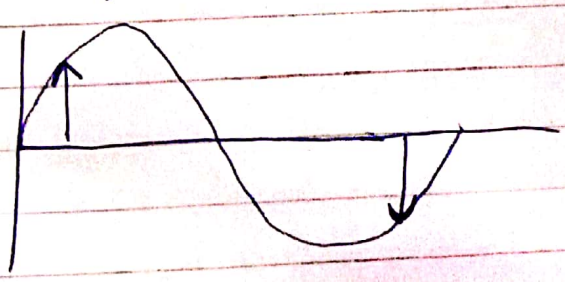
1 cycle ko sample karne ke lie bit stream ka value infinite hoga

because analog ko continuous rkhna hai



We use Nyquest - theorem

says infinite sampling nhi.
Jo maximum frequency hai usse 2o uske cycle me 2 bar sample karo



Sampling rate = $2f_m$

Each sample ko multiply by n (no. of bits)

i.e $2f_m \times n$

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Telephonic

f_m = 4 KHz

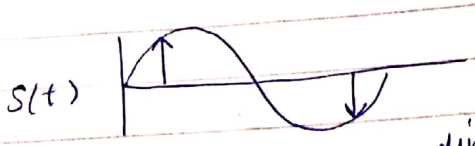
× 2 = 8 KHz

Sampling rate = 8000 samples

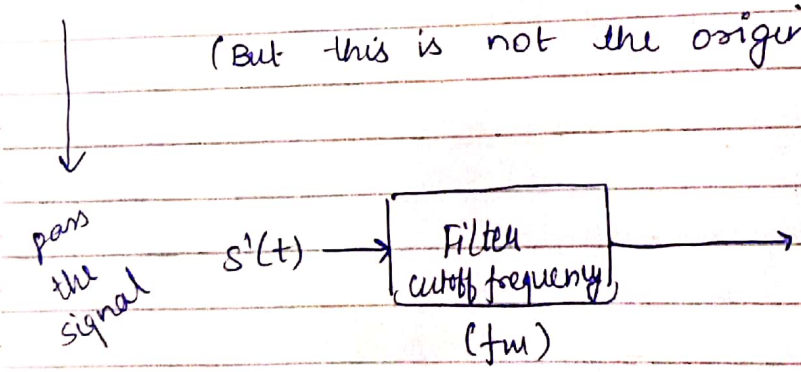
8 bit used to ~~con~~ decode ~~anato~~

= 8000 × 8

= 16000



(But this is not the original signal)



∴ filter will take signal with frequency with f_m and ~~values~~ signal frequency lower than f_m

Higher frequencies ko eliminate kar dega

sample

Music channel

.mp

Scanned by CamScanner

maximum
sample twice the frequency
and use 8 bits for each sample.
i.e decode each
sample using 8 bits.

Music
Channel 1

f_M
20 KHz

S_{rate} = 40000 samples per second

$n = 16$

Channel 1 = 40K x 16
= 640 K

2 Channel use hota hai = 1280 Kbps

.mp3 compression lga ke bhejo.

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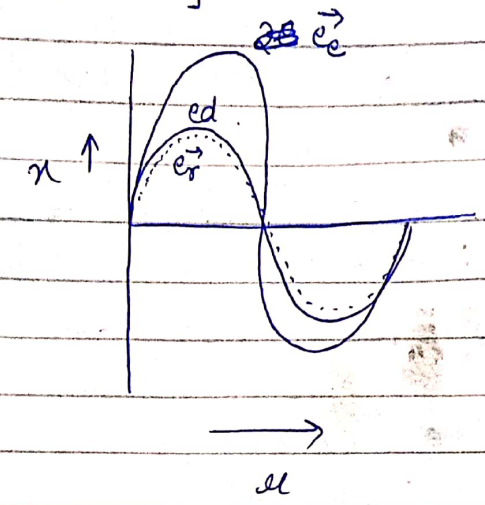
12/03/19

Multi-Path Fading

Graphically



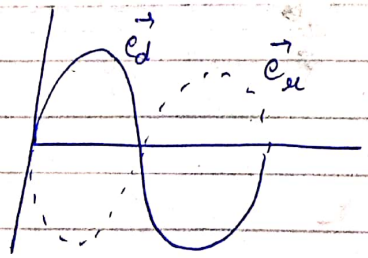
Phase diff. (λ)

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

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

π ↓ opposite phase, negative sign

$$\vec{e}_e = 0.$$



Take d

$d_1 = \lambda/4$ what will be the

$d_2 = \lambda/2$ effective wave $\vec{e}_e$

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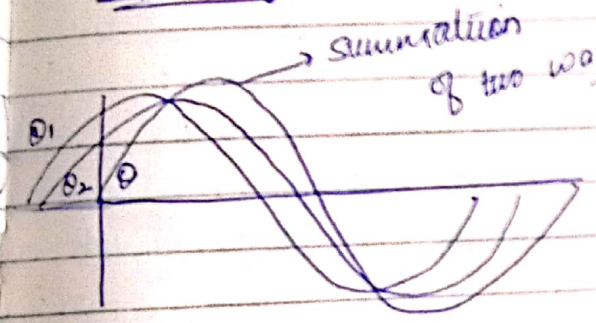
Q. In a mobile comm., the receiver 3 waves with these phase differences. Comment on multi-path fading.

Summation of two sin wave is a sine wave

$= \vec{E}\sin(2\pi ft + \phi_1) + \vec{E}\sin(2\pi ft + \phi_2)$

Graphically



$I = I_m \cos\Theta_1$

$I = I_m \cos\Theta_2$

$(\Theta + \frac{\lambda}{2})$

π

↓

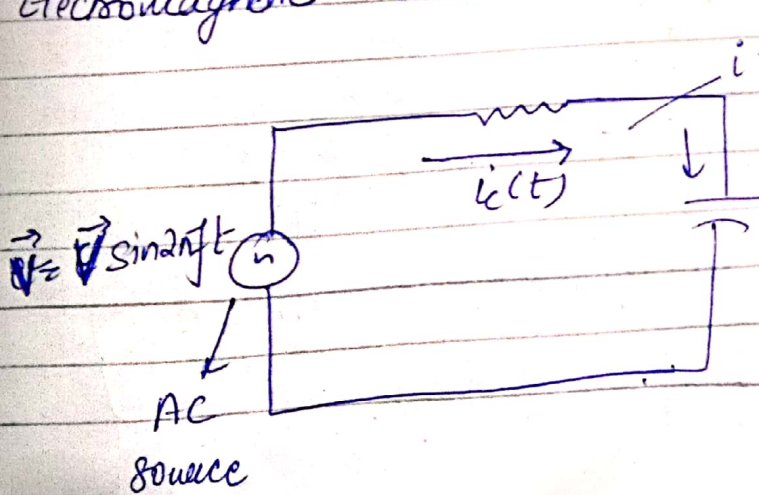
opposite phase

negative hoga

5 marks question (Total 20)

Choice (any 4)

Electromagnetic Wave Generation/ Propogation



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Initially the capacitor is not charged during switching on. (no voltage)

* varying electric field generate hoga.

current through capacitor is displacement current-

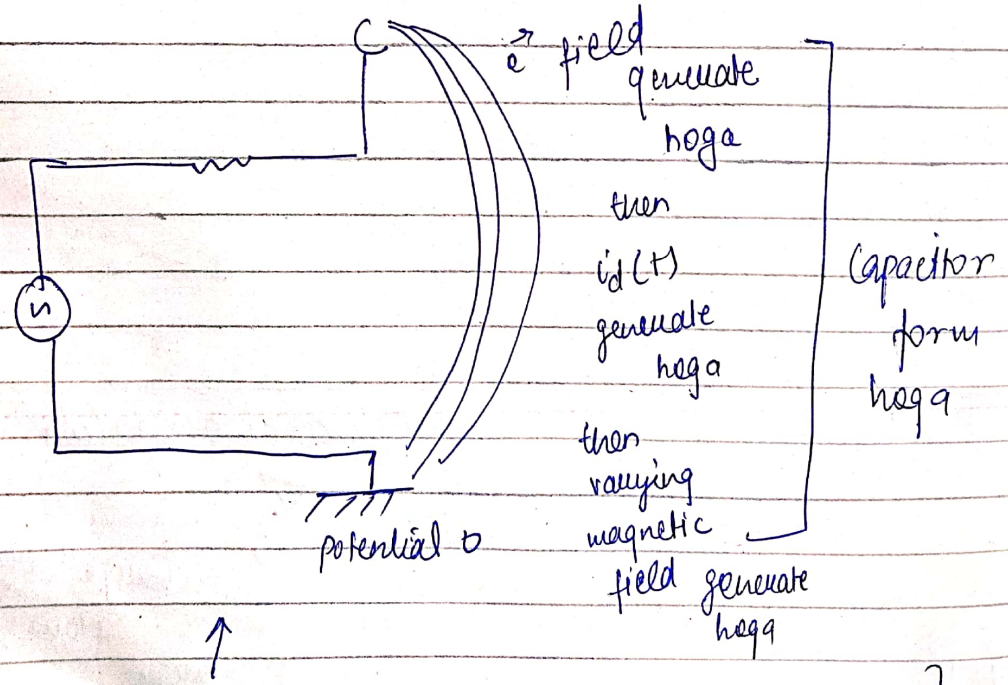
phase diff. b/w voltage & current-.

$i_d(t)$

and current following through all resistor is conduction current.

varying voltage, varying current, varying displacent current

varying charge



[generation of EM wave through an antenna]

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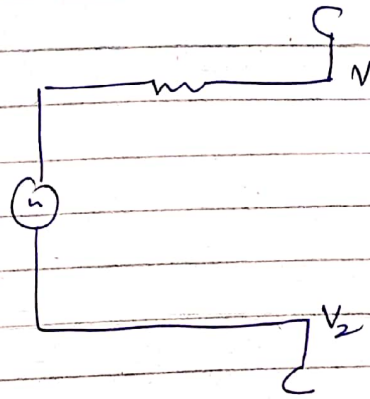
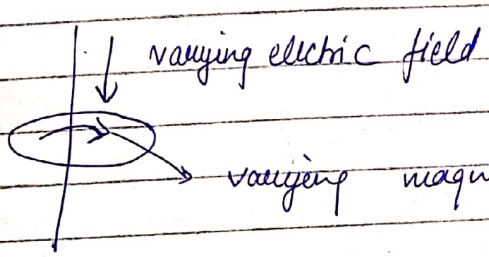
$$V = \frac{Q}{C}$$

$C \rightarrow$ this trends to ∞

voltage tends to be 0.



potential difference is $V_2 - V_1$



Faraday laws.

Q State how the E-M wave is generated by an antenna or received by an antenna.

Wave equation

To derive these we require the analogy of water waves

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

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

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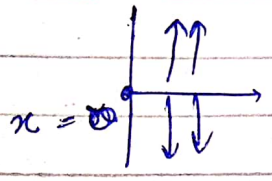
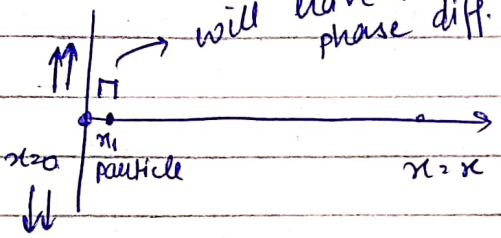
x direction →



aise motion ka hoga of water wave

denoted by $\vec{w}(t)$

$$\vec{w}(t) = W \sin 2\pi f t$$



x_1 will transfer energy to x_2 and x_2 ka harmonic motion hoga bt thodi der me hoga

Usly x_3 ...

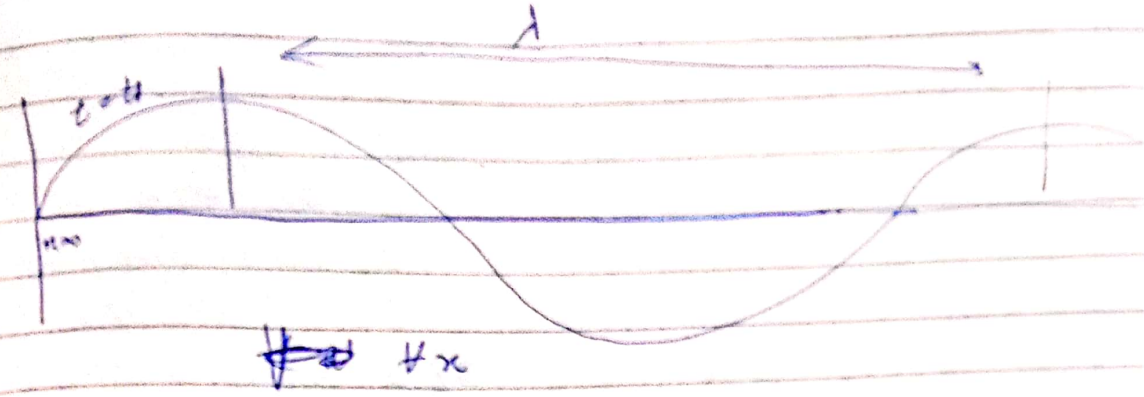
then

$$\vec{w}(t, x) = W \sin(2\pi f t - \phi_x)$$

↳ kyonki particle ka motion bad me shuuu hua to kam hoga.

water wave eqn will be function of t & x

Scanned by CamScanner



at $t = t_2$ wave change ho jaega

So.

$$\vec{\omega}(t_1, x) = W \sin(2\pi f t_1 - \phi_x)$$

$$\lambda = 2\pi$$

$$1 = \frac{2\pi}{\lambda}$$

$$x = \frac{2\pi}{\lambda} \cdot x = \phi_x$$

So.

$$\vec{\omega}(t_1, x) = W \sin\left(2\pi f t_1 - \frac{2\pi}{\lambda} x\right)$$

T time me λ distance travel hoga

$$1 = \frac{\lambda}{T}$$

$$v = \lambda / T \Rightarrow \boxed{v = f\lambda}$$

Scanned by CamScanner

Capacitor value change karo oscillator se different frequency generate hoga

(Tuning circuit)

Speed of EM wave = Speed of light

in space, aerospace & metal.

Space me 3×10^8 m/sec

aerospace me 1cm hojata hai

metal me aur km hojata.

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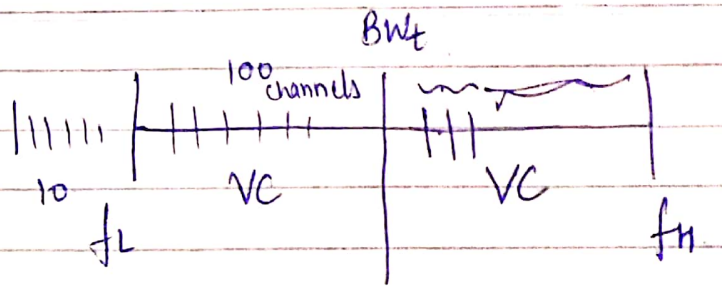
27/3/19

FDMA / FDD



BW_{UL} BW_{DL}

110 channels are allocated within which 100 channels for voice & 10 for control

110 channels are allocated

uplink - call request

downlink - paging slot, grand channel (anybody can access)

voice channel are created from normal frequency slots

and control channel are created from mini frequency slots

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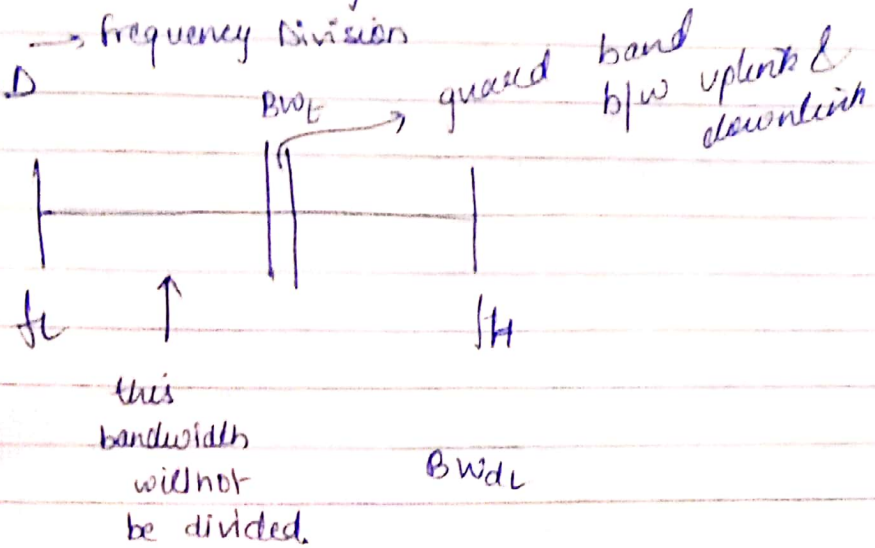
TDMA / FDD

One channel allocated frequency slot allocated to source can be used any time

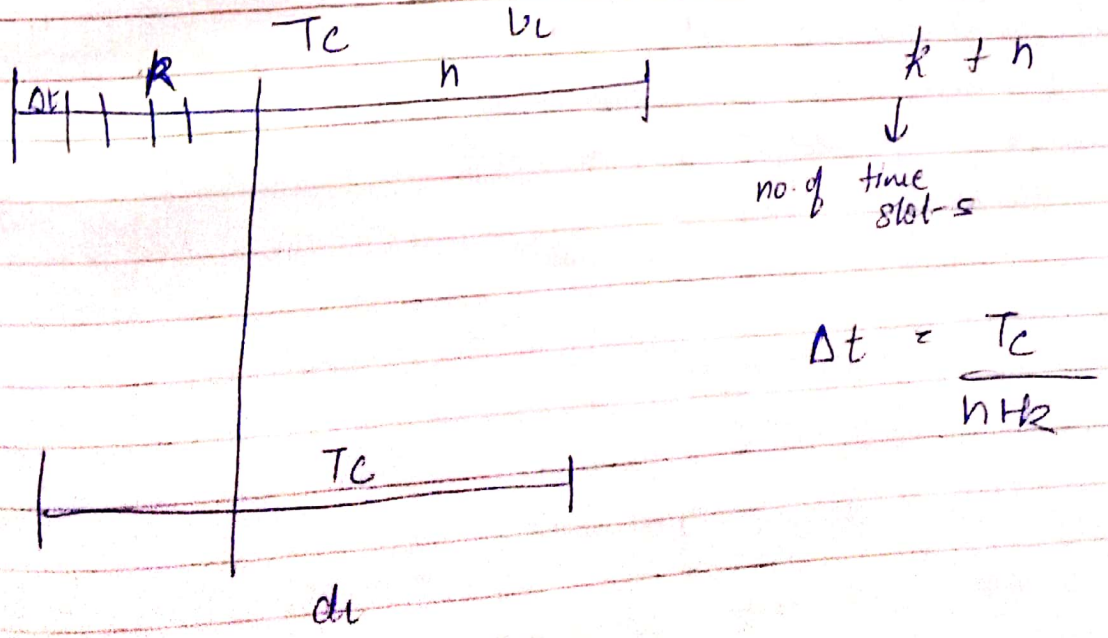
→ frequency division

TDMA / FDD



Here, bandwidth is divided into BW_{UL} & BW_{DL} but not further divided.

Uplink and downlink have different frequency slots



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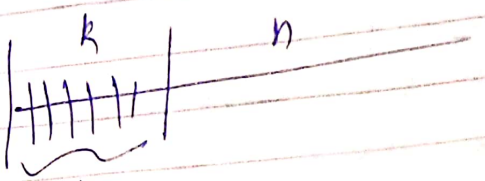
n slots will be allocated created as voice channels (uplink)

Then k ko further divide karo slots me.



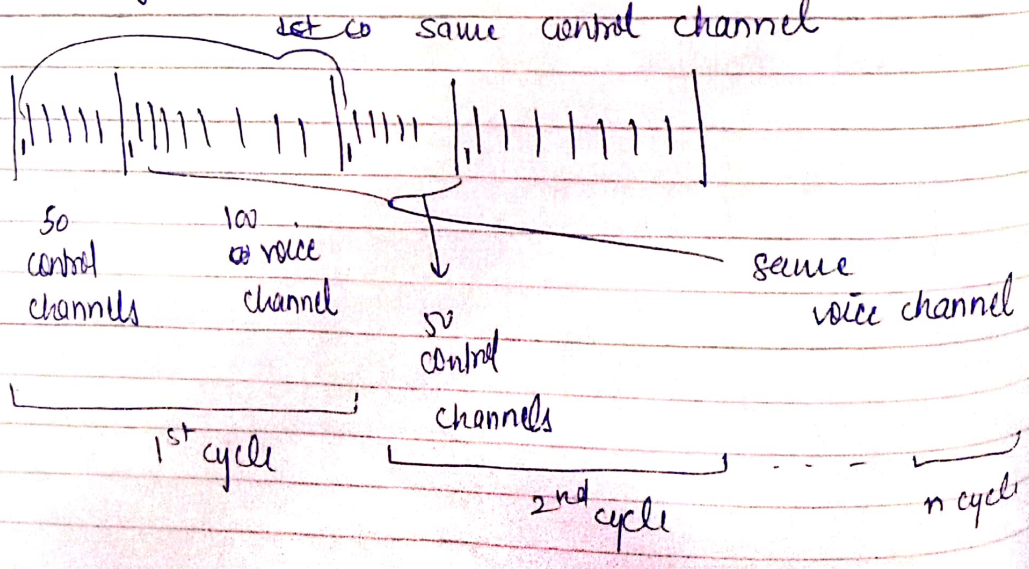
↓

where further divided it become 10 k

↓

no. of slots called mini-time slots

Similarly, for downlink,



Any one allotted 1st control channel (time slot) send the data for Δt. then can only send data on the 1st control channel on next

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slot.

call request
SA
DA

→ digital message

(this message cannot be transferred in the time slot of singal control channel and one cycle)

(How much bandwidth will be used) (the whole uplink)

uplink → CH2 ↓ control slot 2 mila hai

MSi source — MSj destination

ROM me built in hota hai control slot

time calculate karenge when the time will start

~~hats data~~ every message is send with the same speed ~~or~~ for a mini time slot.

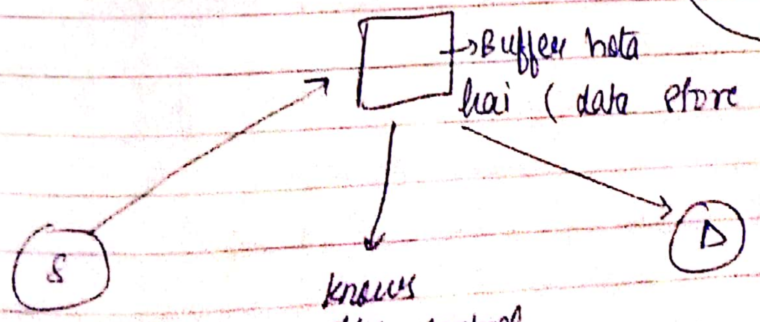
convert digital data → analog using (PSK, QAM)

analog bandwidth = baud rate.

" depend on the uplink bandwidth

this means uplink data rate speed will be same

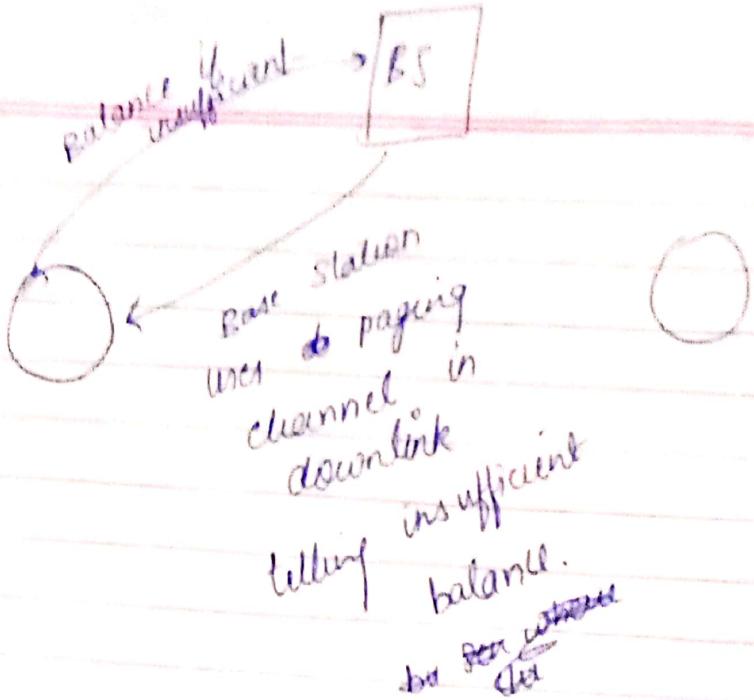
Base Station



Call Page	SN	DN

0, 30, 50, 100

→ Data mil jaega (→ Base Station ko)



If destination is busy, then also a paging channel will be used to send to sender that destination is busy.

If not busy, sufficient balance then need to allocate voice channel to both sender & destination

check karega

1 pair of uplink and downlink voice channel hai ki yeh ni

Grant Channel

If yes

Sender pe paging channel pe Call succesful message bhej phir grant channel pe -?

Destination pe paging channel pe message bhej call coming.

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(5) (1)

4 6 4 6
V d V d.

allocated to sender and desti.

When A

↓

track signal → to start the transmission for uplink

(Base station milega)

1 | 2 | 3 | 4

(4-1) ΔT
(after this time transmission start using the speed of uplink channel

11 sec

(5-1) ΔT
transmission start using the speed of downlink channel.

(But for ΔT time)

data rate increases time cycle reduces.

Source & Destination ka clock synchronization

FDMA me data speed will equal to the frequency slot alloted but in TDMA it will be the complete uplink / downlink.

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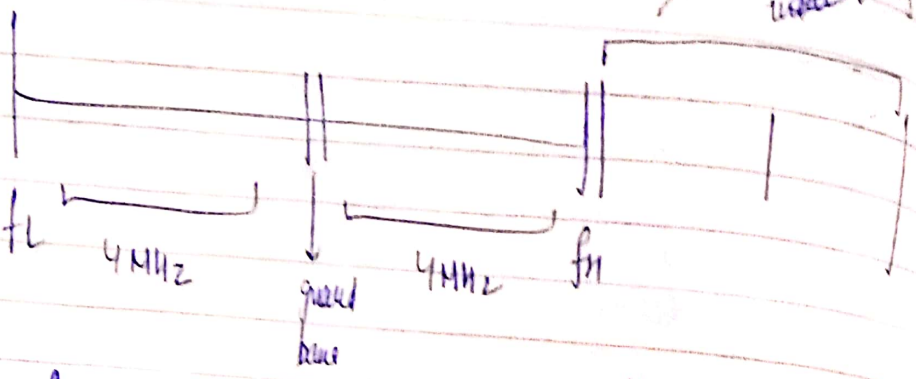
No. of Uplink & Downlink Channels

BW = 8 MHz (allocated to ISP) TDMA / FDD



$f_H - f_L = 8\,MHz$

There is a guard band b/w every bandwidth allocated to ISP

ISP cannot transfer more than the bandwidth allocated.

Using 16 QAM
↳ no. of levels

Average Each channel is speed

$CH = 10\,Kbps$

But they will be transmitting with the speed of uplink bandwidth

Average speed of channel = Uplink bandwidth / n

↳ no. of channels

No. of uplink channels

$BW_{UL} = 4\,MHz$

$BR_{UL} = 4\,MBaud/sec$

Bit rate$_{UL}$ = $4 \log_2 16$

$= 4 \times 4 = 16\,Mbps$

Scanned by CamScanner

Emerging Trend in Computer Networking

PPT

Min - 2
Max - 3

[Roll No - Name Group No]

↓

Sir ko batana

Average speed = $\frac{16 \text{ Mbps}}{n}$

16 Mbps = 16×10^6 bps.

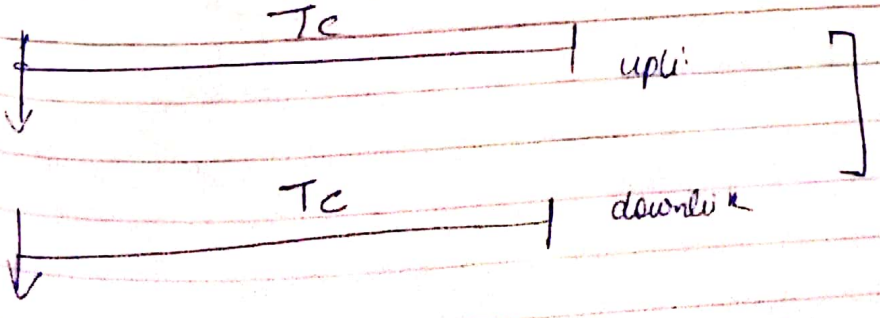
1 channel speed = 10×10^3

No. of uplink = $\frac{\text{Total speed}}{\text{1 channel speed}}$

= $\frac{16 \times 10^6}{10 \times 10^3}$

= 1600

Pehle uplink & down link same ekt the the.



tak aya dono sath shuru ho gye.

overlap kar the the.

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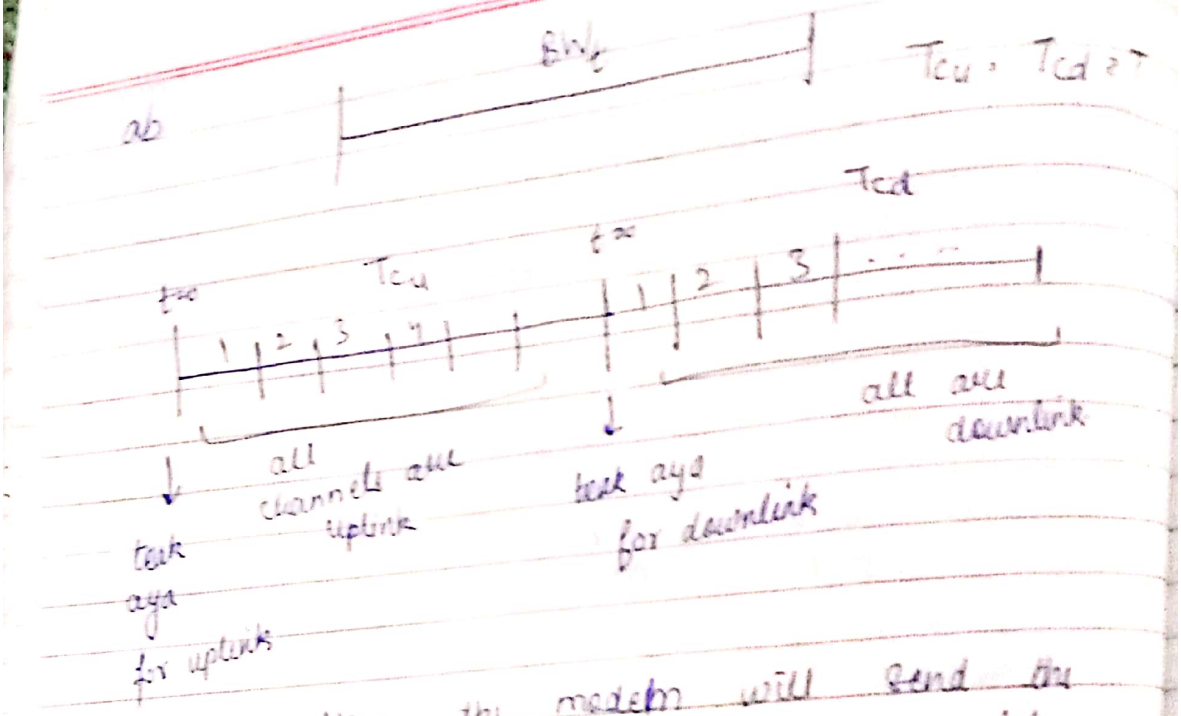
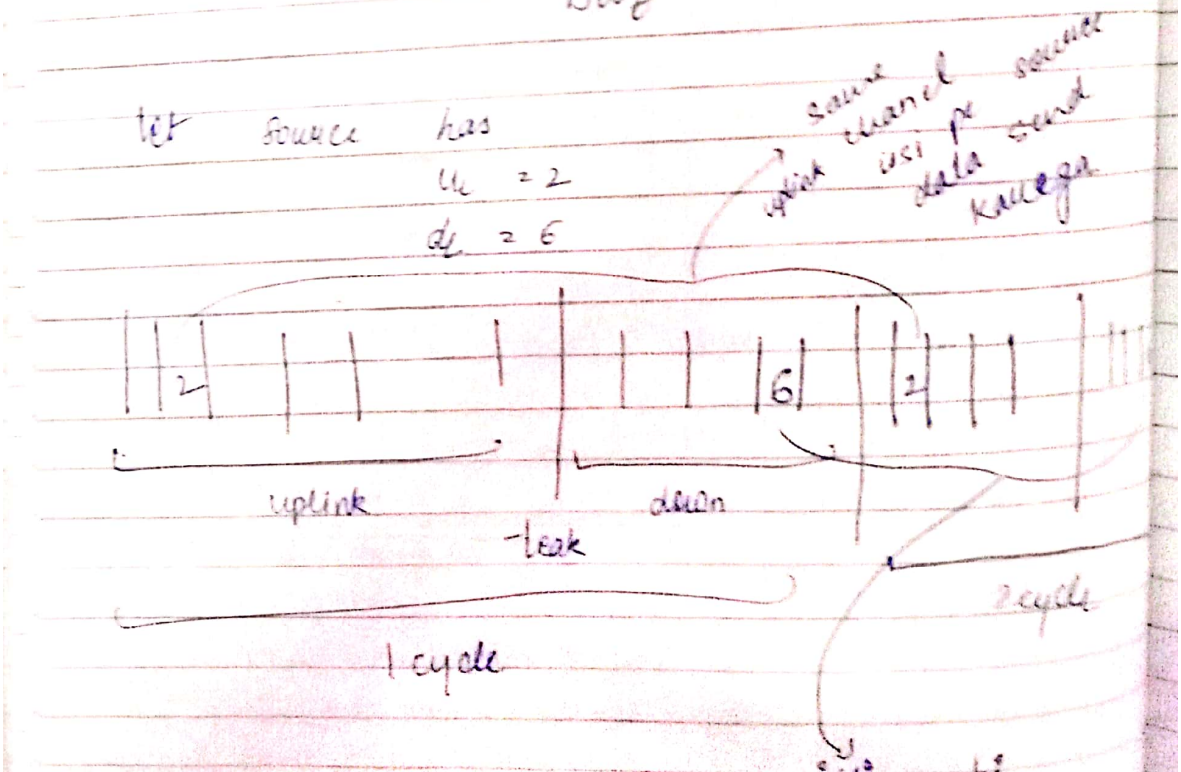
TDMA | TDD — no diversity & bandwidth

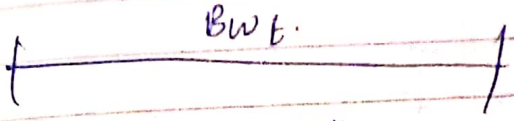


Here the modem will send the data using the complete BW_t



Scanned by CamScanner

speed double ho gya.
Channel come ho gya.



$BW_t = 8\ MHz$

$BR_t = 8\ MB/sec$

~~bw~~
bit rate $= 8 \times \log 16$

$= 8 \times 4 = 32\ Mbps$

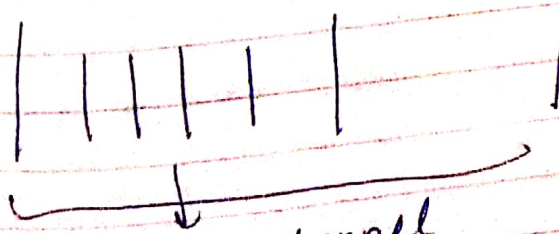
No of channels $= \frac{32 \times 10^6}{\text{~~10 x 2~~ n}}$

total channels (uplink & downlink)

Only for uplink $= \frac{32 \times 10^6}{2} = \frac{\text{No. of channels}}{2}$

~~No of channels~~

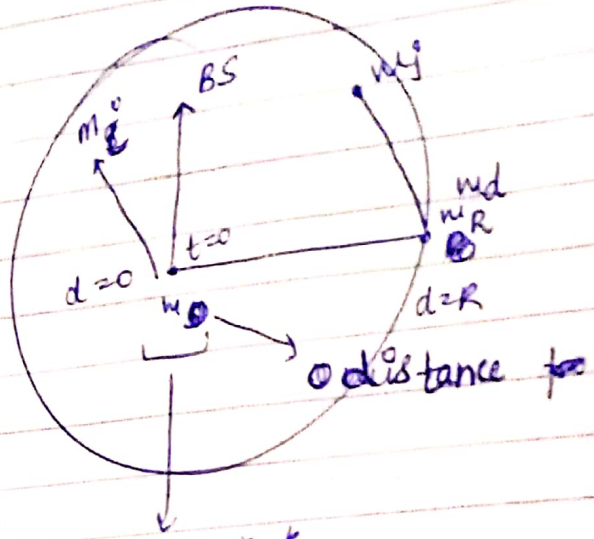
FDMA me bhi



b/w uplink & downlink me bhi

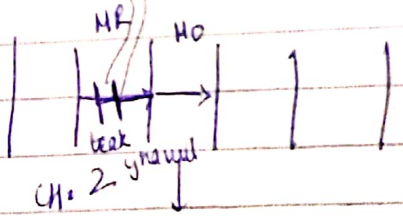
har channel ke beech guard me bhi frequency plot tha

TDMA



transmission will calculate hoga

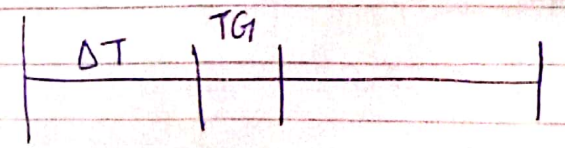
isko leak jldi nikl jaega t=0 pe calculate karke 2 se

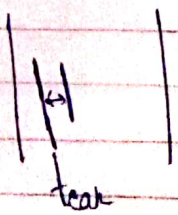


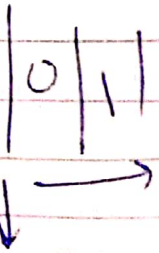
V = EM wave signal speed

$TG1 = \frac{2R}{V}$ → radius of cell

$td = \frac{R}{V}$







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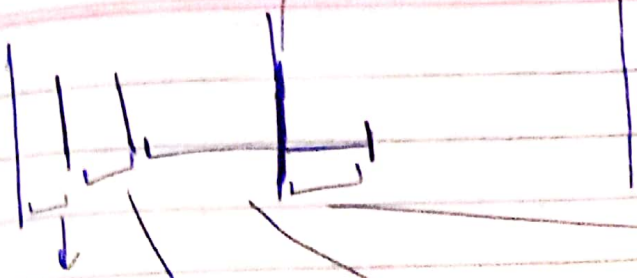


idhar BS ko Mo & MR ka data milega & interference hoga

yha leak mila BS se phir transmi

iske bad transmission shuru hoga

isme transmission hua to the BS and since Mo

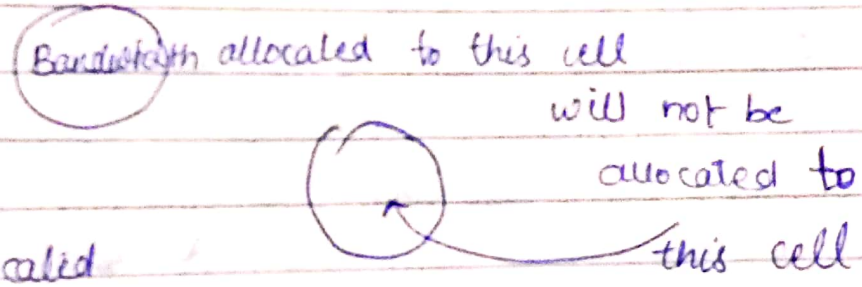
29/3/19

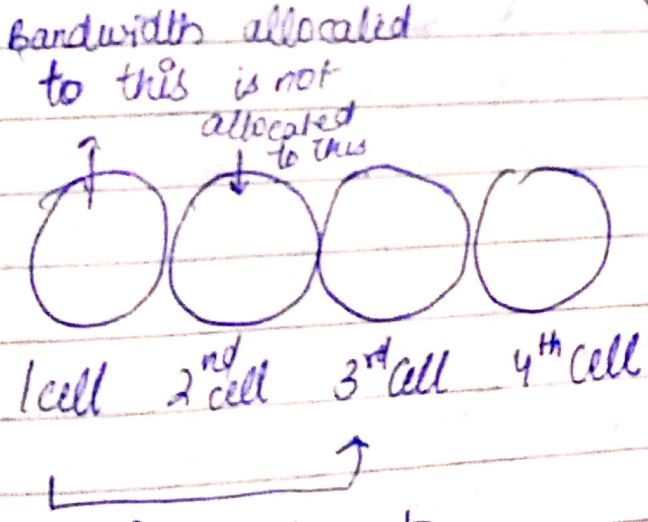
CDMA / FDD

Code Division Multiple Access

SDMA — ?

Space me bandwidth cells hai





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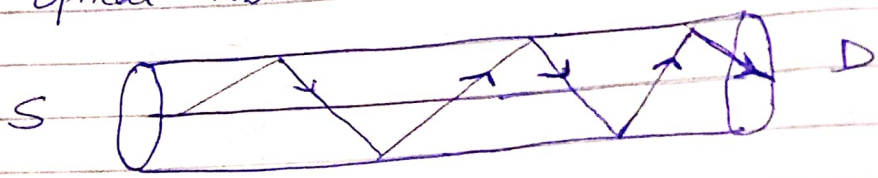
Optical fibre me hum wavelength ki baat karte hai.
we say we are communicating using wavelength

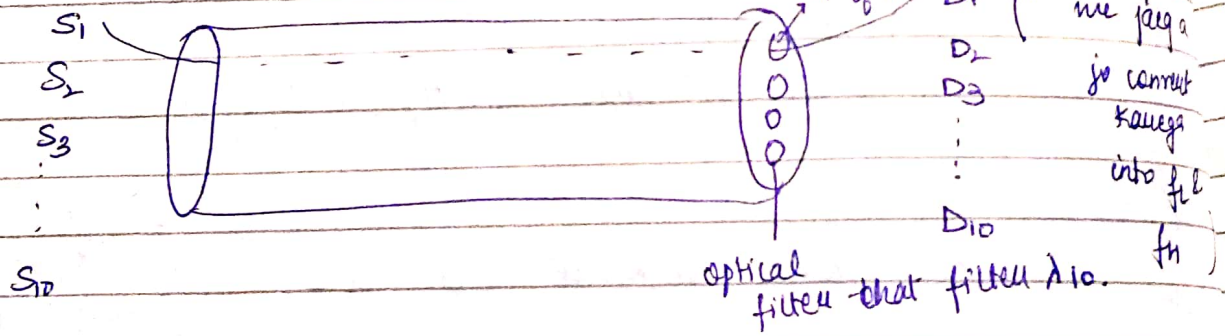
optical fibre



λ length ka signal bheja (i.e one color)

electric-optical (laser)

optical-electric



Each source will send signal S_1 with wavelength λ_1,
then S_2 in λ_2
All signals with different λ will mix and at destination signals we will seperate signal with their resp. λ's.
(using optical filters)

Mobile Communication → FDMA, TDMA, CDMA

Scanned by CamScanner

CDMA / FDD

In this, we have 'n' codes

A B C D ..... n^{th} code (uplink)
i.e these codes are transmitted using BW_u.

A B C D ..... n^{th} code (downlink)
i.e these are transmitted using BW_d.

11 bit Code

2^{11} → 2048 channels
↳ 1848 as voice channels
200 for control channels

European Standards

1G - FDMA / FDD - AMPS
2G - TDMA / FDD - GSM
TDMA / TDD

2G - CDMA (USA Standard)

3G CDMA - WCDMA
4G CDMA
5G CDMA

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maxi-pedia.com
www.maxi-pedia.com/vickrey+auction

2G CDMA

m bits for code (both uplink & downlink)

2^m codes
(all codes will not valid)

let a code 8 bits.

A → 10101100 (code)

B → 11001101

data ki bits called logical bits 0, 1.

let A & B be uplink codes for S1 station & S2 station

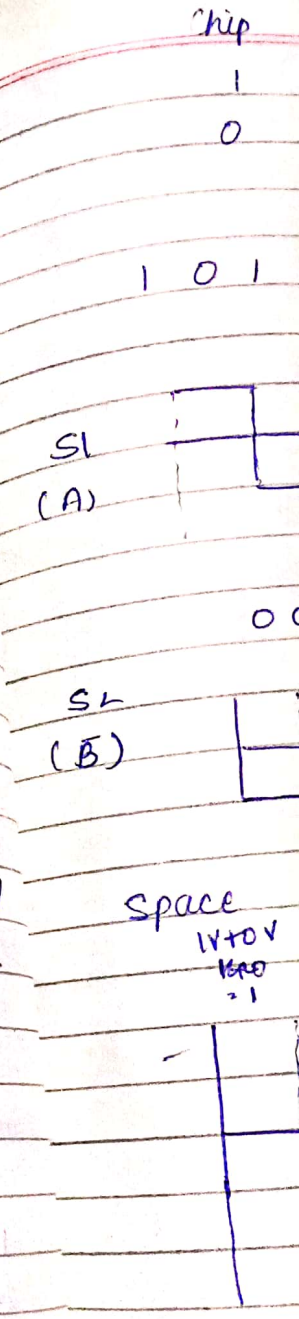
To send 1 bit, S1 has to send ~~corrupte~~ code A
then each bit in code is call sub bit or chip
i.e 8 chips need to be transferred to send logical bit 1.

To send 0 we will send $\bar{A}$

Similarly, will send

B to send 1 = B

to send 0 = $\bar{B}$



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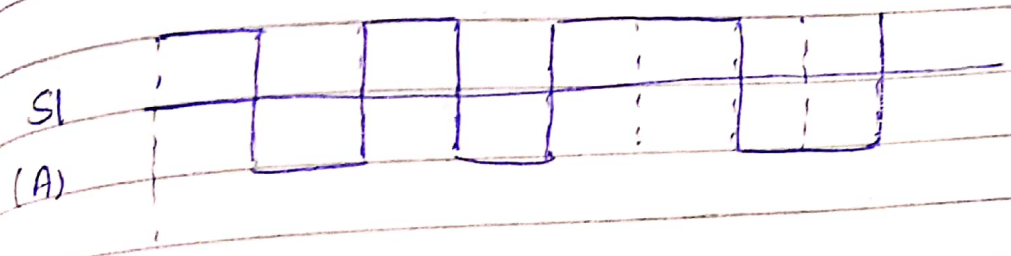
Chip

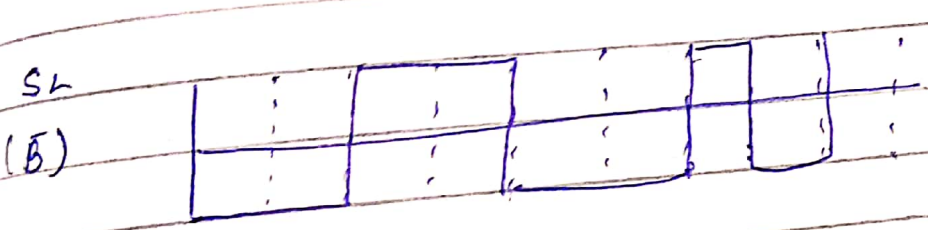
1 = +1V

0 = -1V

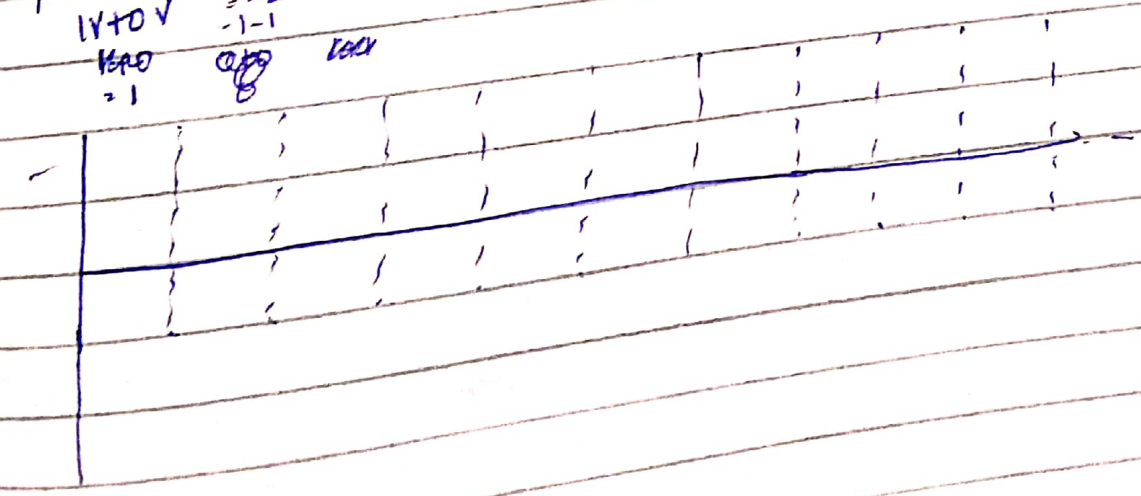
1 0 1 0 1 1 0 0.



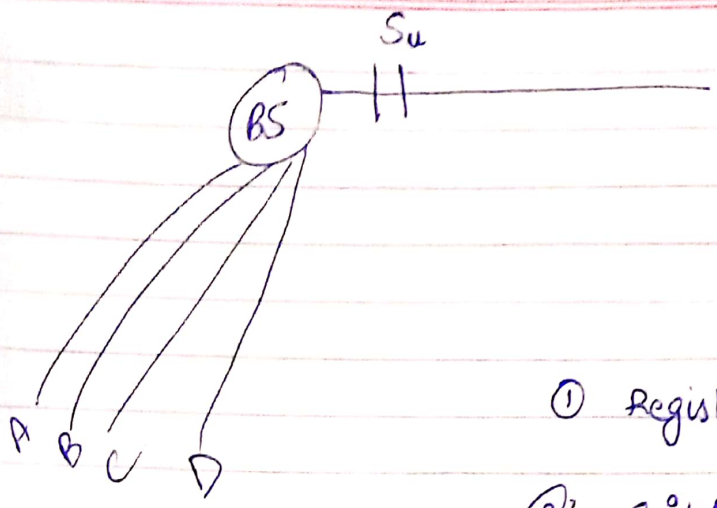
0 0 1 1 0 0 1 0



Space wise S1 & S2 will be combined.



→ resultant of all stations i.e A, B, C & D



① Registering with the Company

② Switch ON the phone
7 base-stations around you contact you and the BS that ~~tha~~ has the highest signal strength.
you send the acceptance
i.e you registered with the base station.

then

parallel hoga

S_1 A → +1 (station has send 1)
→ 0 (station has not transmitted)
→ −1 (station has send 0)

S_2 B

S_3 C

⋮

S. N → ~~Con~~ no. of sources

Ji the stations honge unke lie buffers honge

input buffers

output buffers

(initially pointer 0 hota hai)

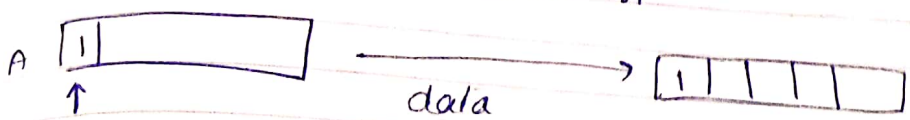
Input-

A ↑ ↑ m bit

output

~~Layer Station A~~

Station A has send A



data transfers to (parallely)

Base Station Knows A ~~ka output~~ connection H ko jana hai

H

Base station calculates Su i.e uplink.

~~Now after~~ Now H will be receive the data that the BS will send but H ~~will~~ has his own code vo send karega.

to vo S_d calculate karega.
sb receiver ka resultant hoga.
aur bhej dega

~~$S_d \cdot A$~~
~~$S_d \cdot B$~~
~~$S_d \cdot C$~~

$S_d \cdot A$
$S_d \cdot B$
$S_d \cdot C$

m bits

$C = \{0, \ldots 2^m - 1\}$

allset of codes

not all codes will be valid

so

$C_r \subset C$

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→ Orthogonality Property

(1) $$S.T = \frac{\sum_{i=0}^{m-1} S_i . T_i}{m}$$

To Two codes are valid

A code is valid when

pick a code let S from C.

and then two a dot product with rest of the codes

and if i = rest codes in C

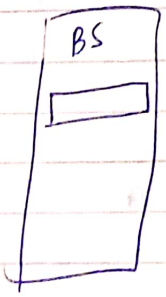
$$S.T_i = 0$$

then S is a valid code

If

A $\bar{A}$ A $\bar{A}$

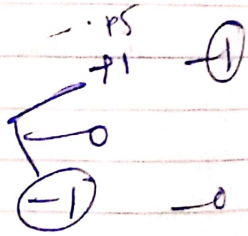
1 0 1 0



Input

(H) (H) $\bar{H}$

G $\bar{G}$ G $\bar{G}$



Sd.H

Sd

H + G $\bar{H}$ + $\bar{G}$ H + G $\bar{H}$ + $\bar{G}$

5/4/19

CDMA / FDD

2 conditions

1.) Send A and $\bar{A}$

2.)

Source Code		1 bit
A	A	1
B	B	0
C	C	1
D	D	X

S :

sum of voltage of all sources (jo jo uske ~~un~~ under me register hua hai)

S_0	S_1	.....	S_7

S generate

Now we need to decode A by S.A $\begin{cases} +1 \\ 0 \\ -1 \end{cases}$

+1 aya to buffer me 1

0 aya to buffer me 0.

-1 aya to buffer me kuch ni haya.

eg $S = A + \bar{B} + C$

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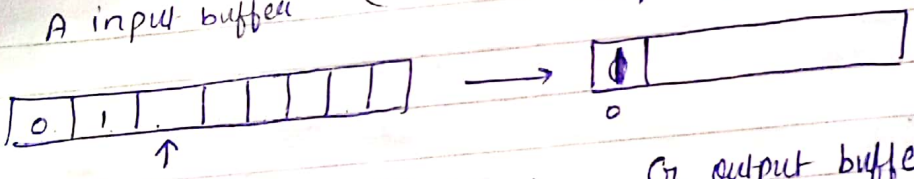
Everyone has uplink buffer / down link buffer

$$S.A = (A+\bar{B}+C).(A)$$
$$= A.A + \bar{B}.A + C.A$$
$$= 1 + 0 + 0$$
$$= 1$$

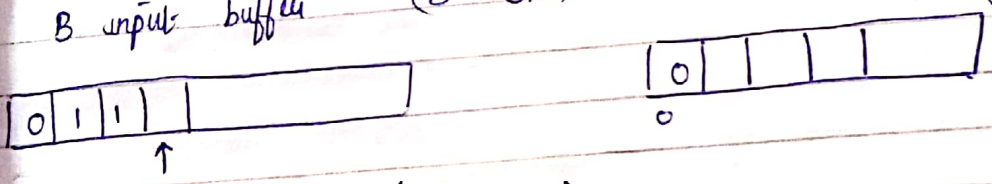
A ka buffer logic 1 daal denge.

$$S.B = (A+\bar{B}+C).(B)$$
$$= A.B + \bar{B}.B + C.B$$
$$= 0 \rightarrow (-1) + 0$$
$$= ?$$

A input buffer $(A \rightarrow H)$ H output buffer



B input buffer $(B \rightarrow G_1)$ G_1 output buffer (in the downlink connection)



$(C \rightarrow K)$

Now, we need to transfer first bit to H & G_1.

So, downlink signal banenge.

$$S_d = \underbrace{\bar{H}}_{\text{1 bit code}} + \bar{G}_1$$

downlink Tick dia

S_d ko downlink me transfer kar denge (All stations will store S_d)

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BS ek hai for every 1 ishi parallel

Ab substations decode karenge.
to sb apna apna karenge.

A — A kuch ni bheja

B

$S_d \cdot A = 0$ (so A will find that iske pas koi data receive ni hua)

A downlink buffer

| 0 | 0 | 0 | . . . |

Z.

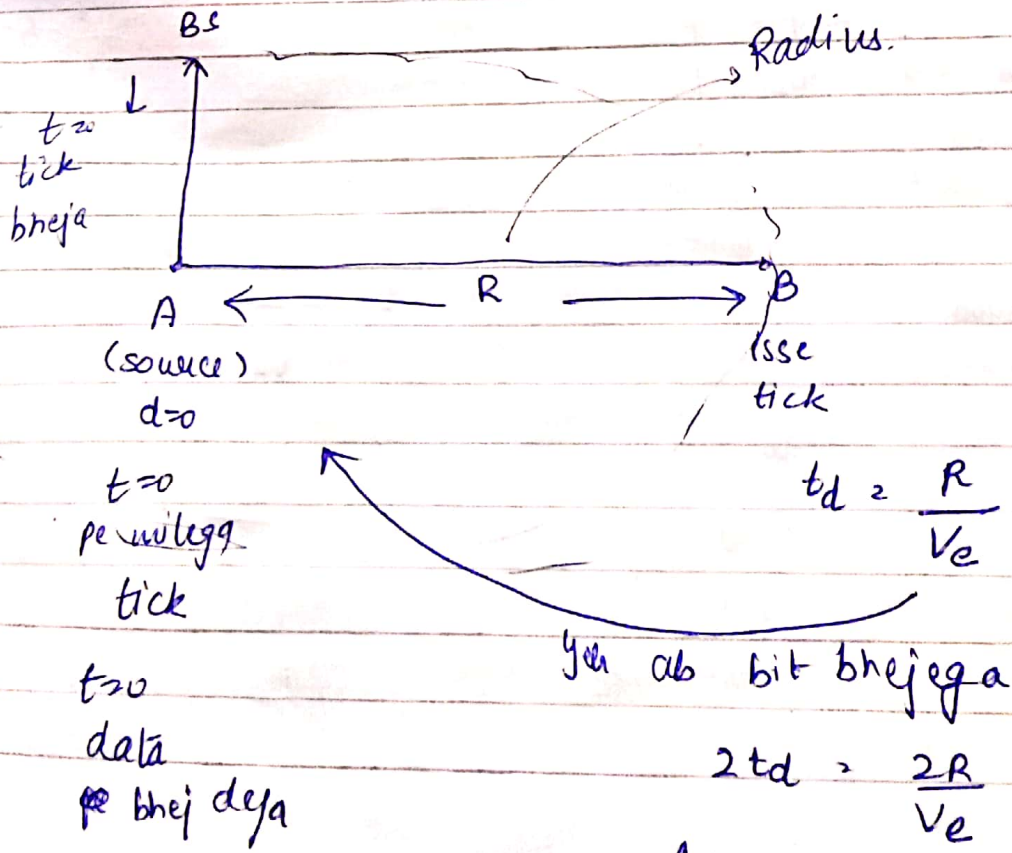
H — $S_d \cdot H = (H + \bar{G}_1) \cdot H$

$= H \cdot H + \bar{G}_1 \cdot H$

$= 1$

downlink buffer me store hota rahega.

→ There will be a synchronization problem.



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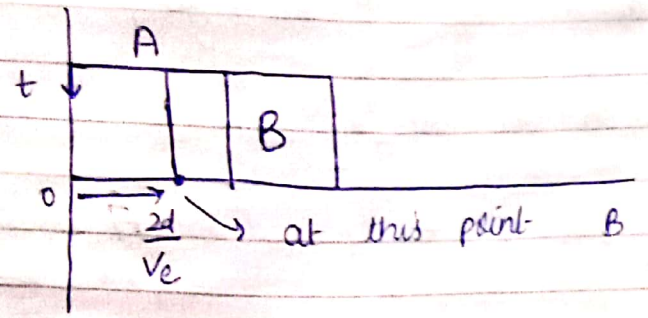
Uplink me hi problem hoga



→ at this point B ka data ayega +

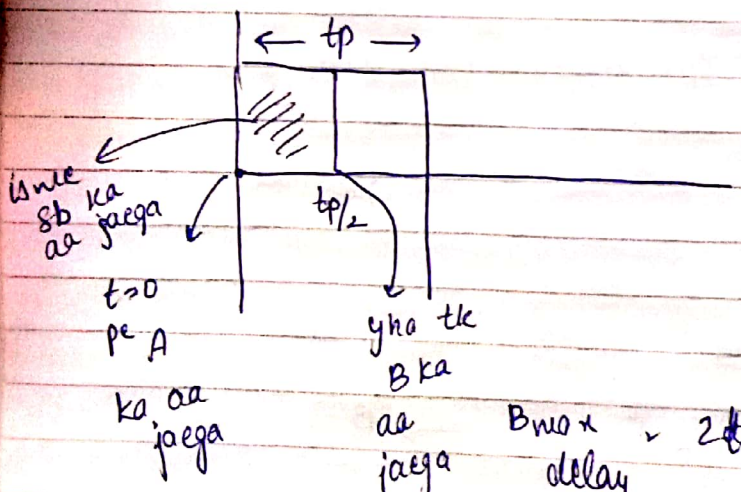
A ne +1 dia base station hoga
B ka ni aya

to Signal +1 −1 =0 ho jaega.

~~or~~

to yeh galat addition hoga.

To solve the problem.



chip kaise ek chip bhejne ka time tp.

chip rate = C_r

$B_{max} = \frac{1}{2d} = \frac{2R}{V_e}$ delay

$tp = \frac{1}{C_r}$

to S yha calculate kar lenge.

$= \frac{tp}{2} = \frac{1}{2C_r}$

$\frac{2R}{V_e} = \frac{1}{2C_r}$

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$$R = \frac{V_e}{4C_r}$$

$$R < \frac{2V_e}{4C_r}$$

↓

Cell radius

$R \uparrow$ to increase radius

$C_r \downarrow$ decrease chip rate

- TDMA / FDD
  TDMA / TDD
  ] Comparison with CDMA / FDD

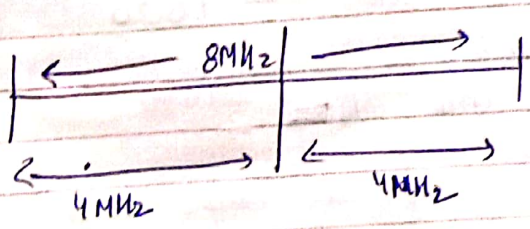
CDMA / FDD

BW = 8 MHz → Bit ka chips ni ka transmission rega

QAM = 16

Ch rate = 10 Kbps

For Uplink



↓

Voice channel Calculations and we will do for uplink.

BW_u = 4 MHz

BR_u = 4 MBps

BR_u

Chip Rate u = 4 chip / Baud × 10^6 × 4 MCPS

(Mega Chip Per Second)

1 channel ↑ ina bhejega

1 station ka data rate 10×10^3

uplink channels n_u =>

Bit Rate = $n_u \times 10 \times 10^3$ bps

(for 1 bit)

Each code is of m chips

Total uplink chip rate = $n_u \times 10^4 \times m$

1 channel bit rate = 10×10^3

1 channel chip rate = $m \times 10^4$

$m = \frac{16 \times 10^6}{10^4}$

$m = 1600$

Total, no. of chips codes = 2^{1600}

(all chips will not be valid)

no. of valid chip codes = $v \ll 2^{1600}$ (very very less than)

v = no. of channels created.

$v \gg 1600$

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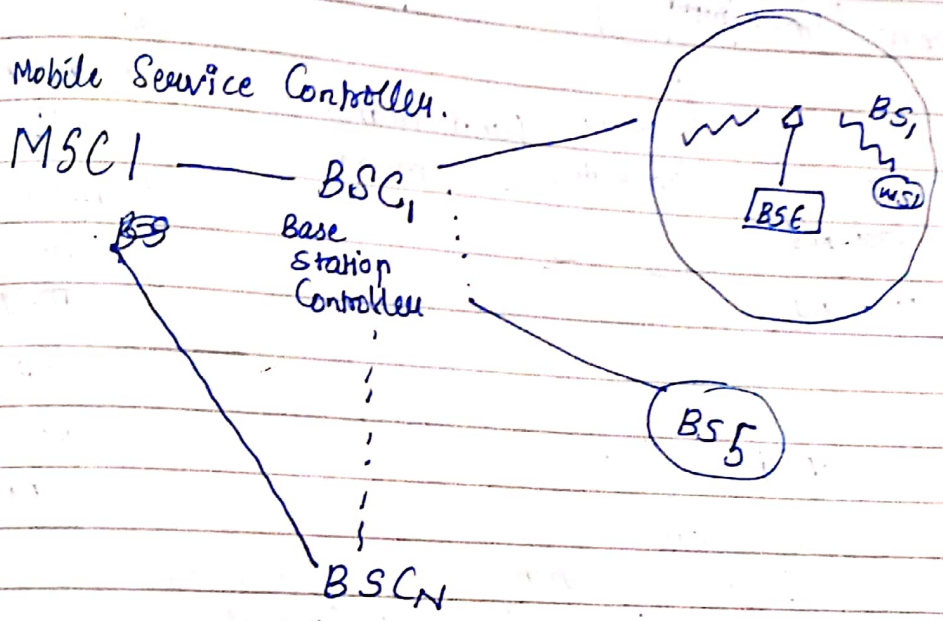
24/4/19

GSM Networks



Every service provider has his own MSC

MSC has two database (many more also are)

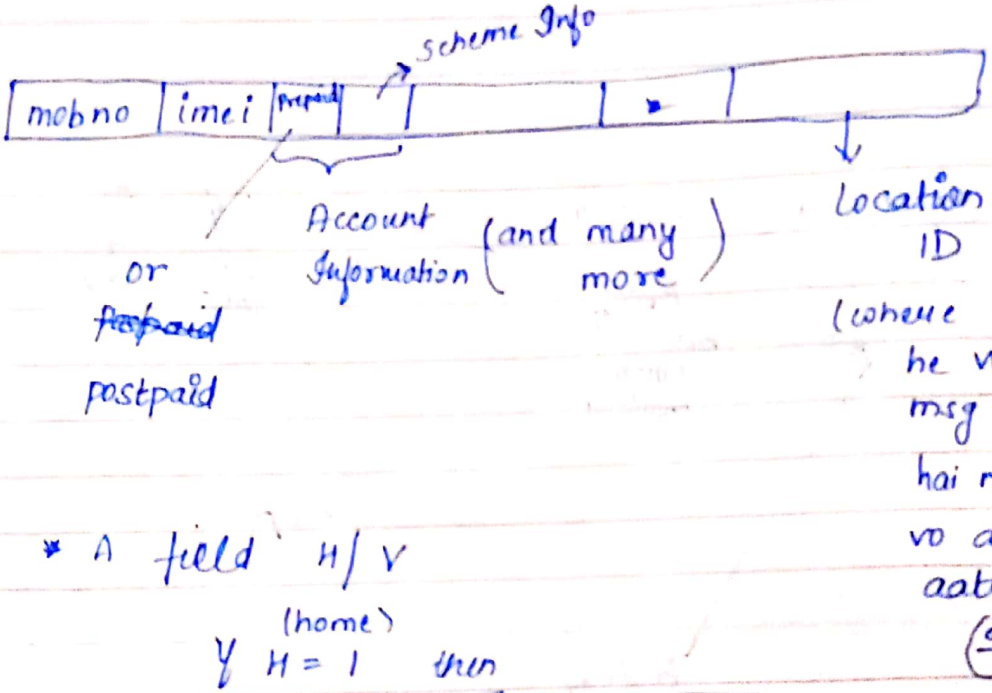
HLR VLR

When we approach a service provider
sim-card with
It has a number and IMEI
↓
International Mobile
↙
Combined with device-no to find theft.

An entry is created in HLR

Scanned by CamScanner

Delhi will have an MSC which will have an entry in HLR.



* A field H/V (home)
If H = 1 then BSC id and BS id also are columns.

or

H=0
when in another city

Mobile will be surrounded with 7 base stations
So, need to register to any one base station
(Random Access Channel ke through)
dedicate control channel pe
data location update hoga.

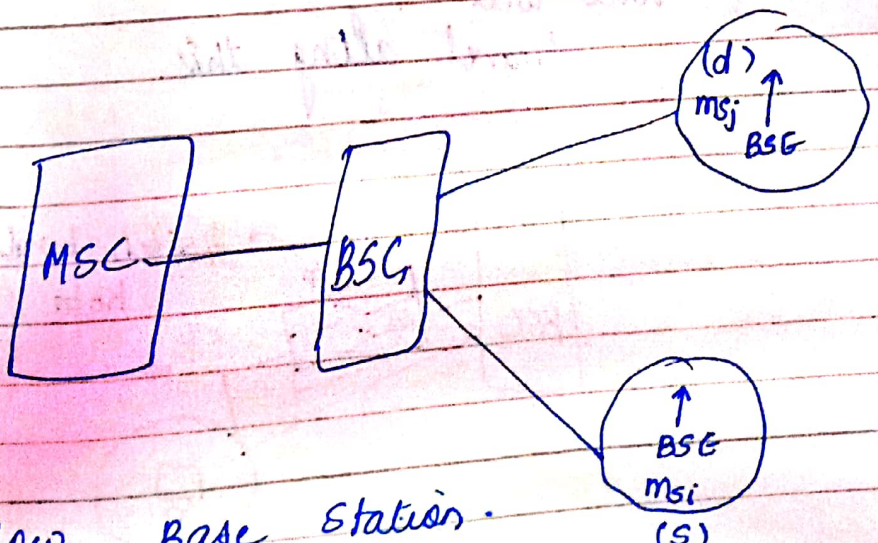
BSC pas jaega apna identification add

kaunsige MSC me jaega MSC uss mobile se check karega ki home MSC hi hai
to entry will be
H=1, BSid BSCid store kar dega.
phir scheme ke according call ho skta hai ya ni.

Balance agar hai to destination check kia (uska same MSC hai ya nhi)
and also phir BSid & BSCid agar same hua to same base station hai.

If destination is free. to sender & destination ko uplink & downlink channel milega

If destination ~~ko~~ free ni hai to sender ~~& receiver~~ will get a paging message that ~~receiver~~ ~~sender~~ is busy.



Now Base Station different hai.

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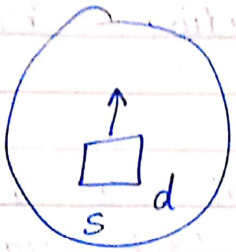
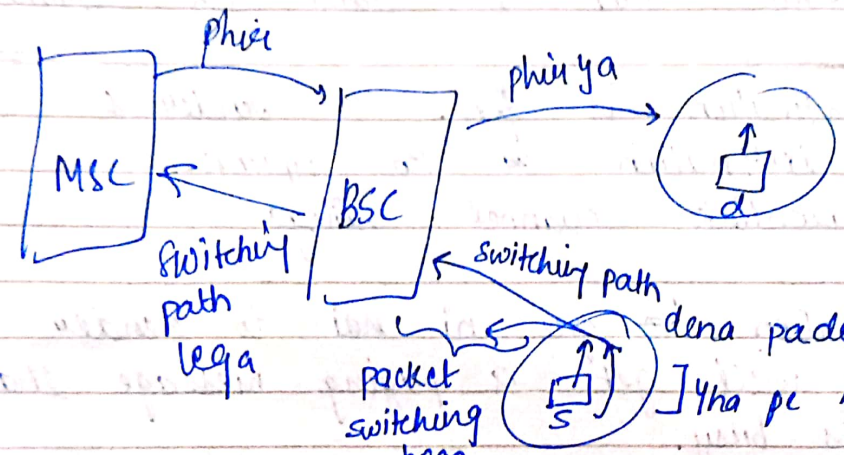
To MSC check karega hone MSC same hai pr different BS. So, check karega destination free hai ki ni

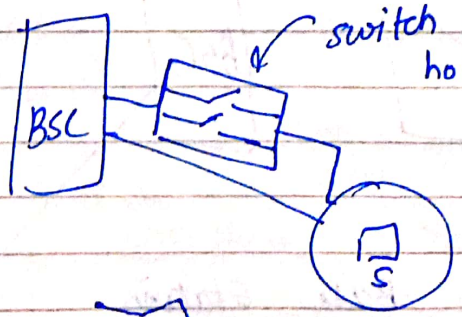


If source & destination same hai to. AR interface se



Yha pe AR interface hoga

voice will travel along this.



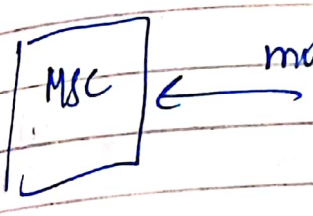
switch bnd kia switch busy hoga —

Scanned by CamScanner

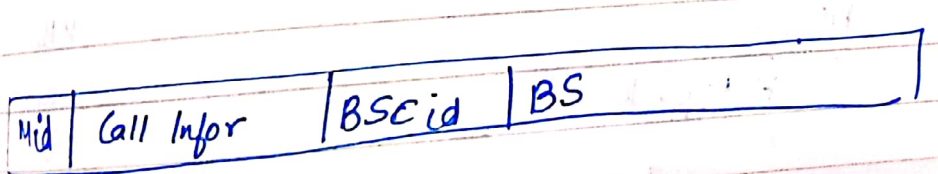
- jb bhi data bhejna hai from BS to BSC (i.e switch ko reserve karna) jb same release ho jye to unreserve kr do. (again sb serve hai) to kehte hai network busy.

Disconnect ke liye pehle AR interface will be given back to BS. and switches ko open kar dete.
Switches can be controlled by BS & ~~BSD~~ BSC.

If Destination ~~is not~~ has not same MSC



VLR

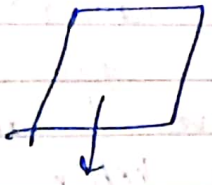


phir ~~to~~ usko message bhejenge.

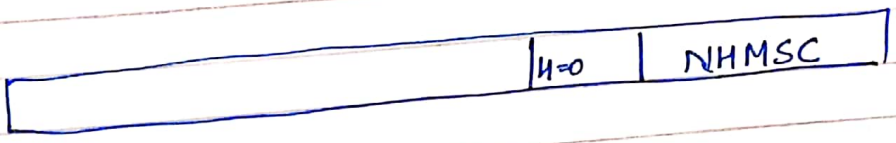
jb home MSC bhejega.

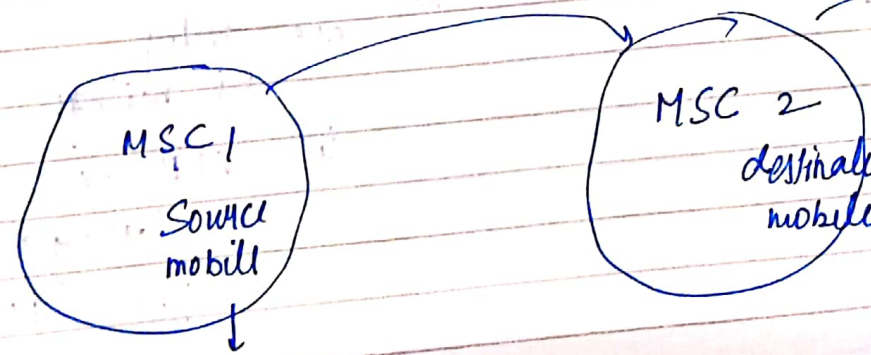
Scanned by CamScanner

phone Home MSC



HLR
me entry ko
update krteye
i.e H=0 kar
dega aur BSCid e BS
ki jagah
NH MSC ka
id update
kar dega





yha pe HLR me to ni milega Kyonki HMSC ni hai to VLR me dekhega

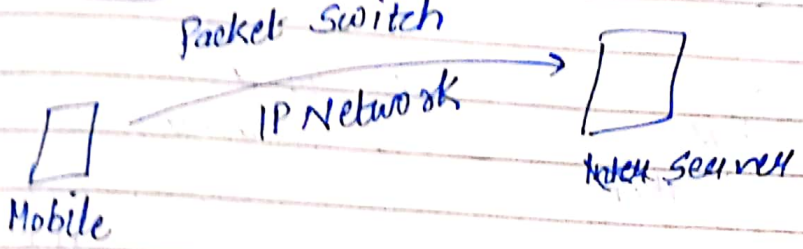
No se MSC HLR me check karega to pta lagega Home me ni hai to NH MSC ki id se data bhejega

Scanned by CamScanner

Switch Allocation & Deallocation ki ye protocol
hota hai Signalling No 7
protocol. protocol.

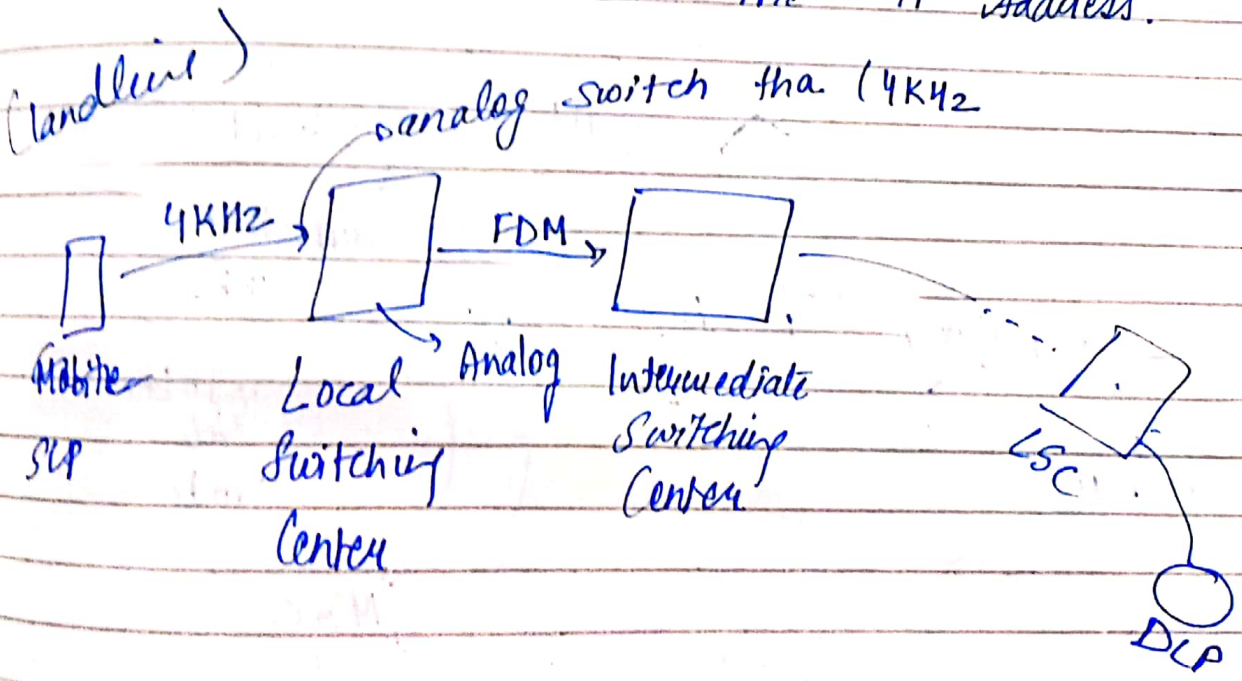
Now Source & destination are not in
there Home MSC.

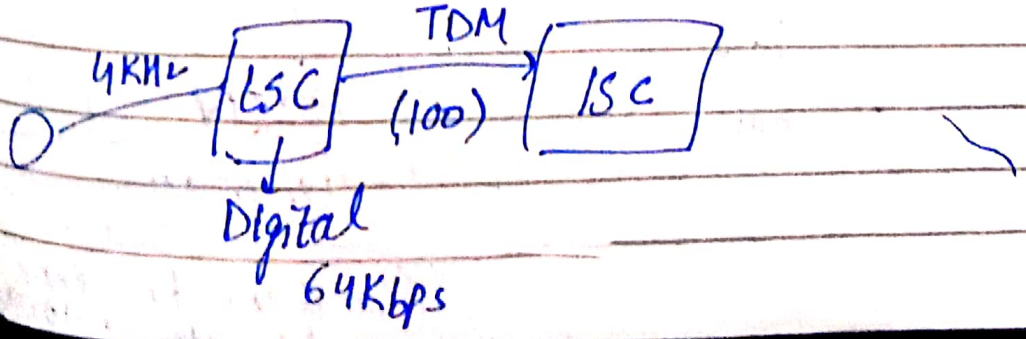
GPRS



Circuit switch me telephone No.
Packet switch me IP Address.

(landline)





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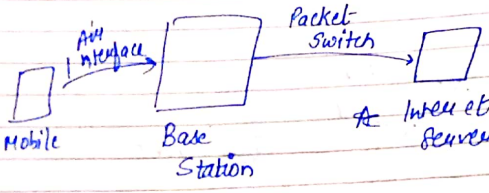
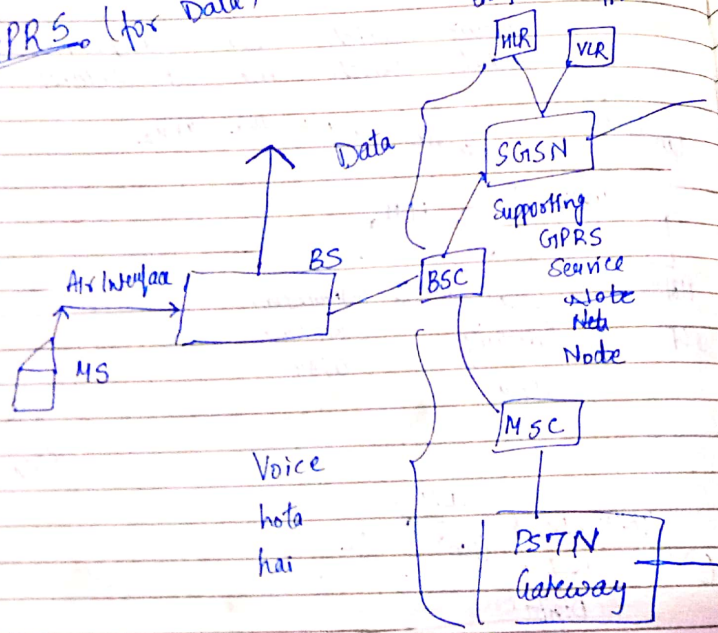
ISDN

GPRS (Data Network)
(source will be (mobile) & destination (Internet server))

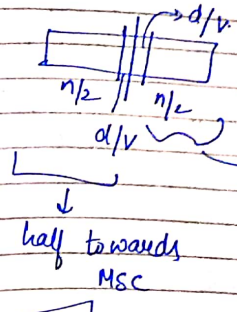
Share the same Air interface of GSM

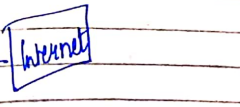


GPRS (for Data)



Now we will know ki yeh voice hai ya data.





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27/2/19

Multiple Access Schemes

- Centralized
  - FDMA - 1G analog (obsolete)
  - TDMA - 2G
  - CDMA - 2G, 3G, 4G, ... (Digital)
- Distributed

FDMA - Frequency Division Multiple Access (European)

- AMPS (Advanced Mobile Phone Service)

TDMA (Time Div. Multiple Access)
- GSM (European)

CDMA - 2G (1995) - USA Std.

3G
- WCDMA (European Standard)
- CDMA (USA Standard)

DISTRIBUTED -

Stations : Laptop / smartphones

Distributed
- Wifi (wireless) - CSMA/CA
- Ethernet (wired LAN) - CSMA/CD

LAN

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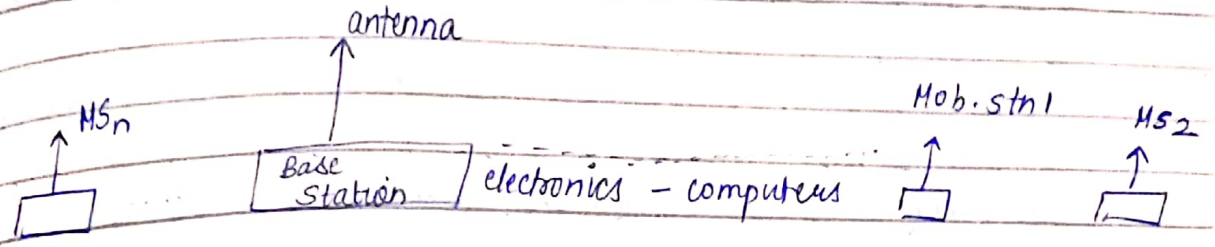
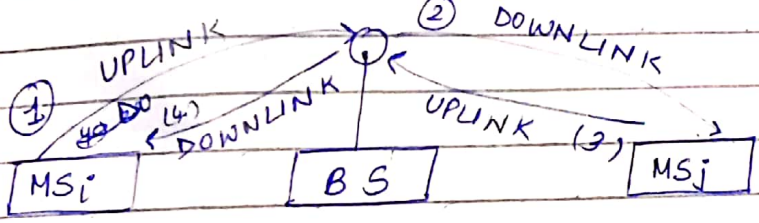
① FDMA (1G analog)



if 2 mobile stations are to communicate;

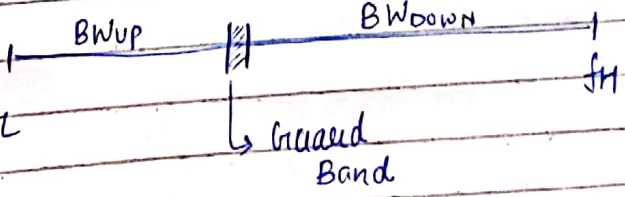
MS1 communicates with Base Station - UPLINK channel
BS " " MSj - DOWNLINK "



Full Duplex - 2 uplink, 2 downlink - to communicate data
↓
not needed for voice

Each service provider has to get a spectrum Bandwidth

→ BW = $f_H - f_L$



→ divided into 2 parts - uplink and downlink
→ high frequency may have power loss
BS can bear power loss ∴ at higher freq. side, there will be downlink communication
⇒ channel at that side

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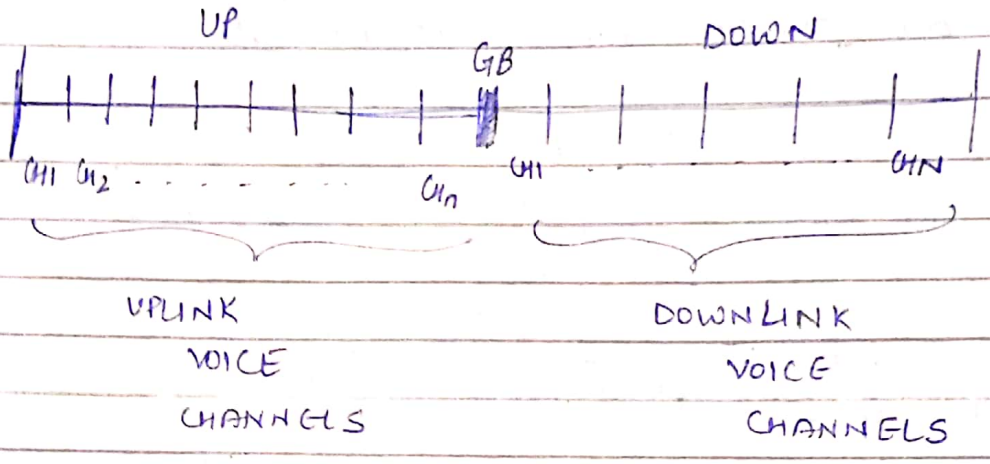
→ In this scheme, 2 can communicate
This scheme is called FDMA / FDD
↓
Freq. Division Duplexing

For more entities to communicate, multiple UPLINK and DOWNLINK channels to be created.



Channel Allocation in FDMA / FDD

→ static
- You create an uplink / downlink channel
- provide 1 each channel to n users
- but some channels will remain idle when not communicating
- no. of users cannot be increased

→ Dynamic - request for obtaining a channel sent to BS

- Channel
  - Voice
    - UPLINK
    - DOWNLINK
  - Control
    - UPLINK – Request Channel
    - DOWNLINK
      - → Paging
      - → Grant Channel
      - → Broadcast channel

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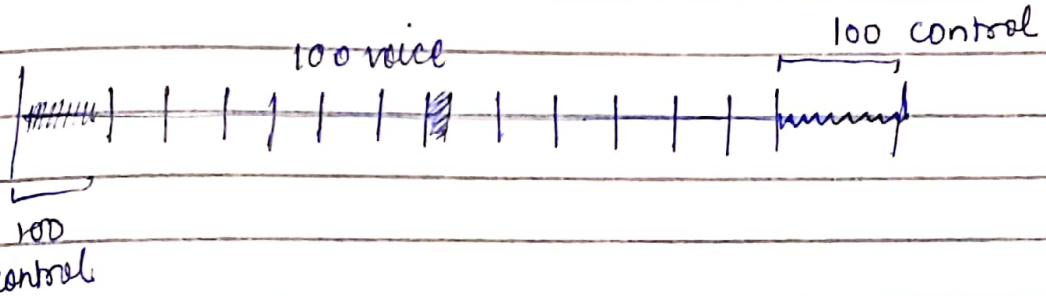
uplink channels = $\underbrace{n}_{\text{voice}} + \underbrace{k}_{\text{control}}$ = downlink channels

- when person A calls, channel A - generates control

request message → | request
source mob. no.
destination mob. no | → sent to BS through request-control channel

Initially, 100 voice channel, 10 control; Further divide each control channel to make 10 control channels because freq. requirement is less as compared to voice :



1- when X dials a number, X chooses ~~chann~~ channel sends request message to BS.

3- B.S. checks if Y (destination) is busy, if busy it sends msg to X through PAGING downlink channel

2- Now BS checks if X (source) has money to place call, if not tells the source through PAGING that no money.

4- If destination (Y) is free, BS allocates an UPLink, downlink channel to the communication and displays

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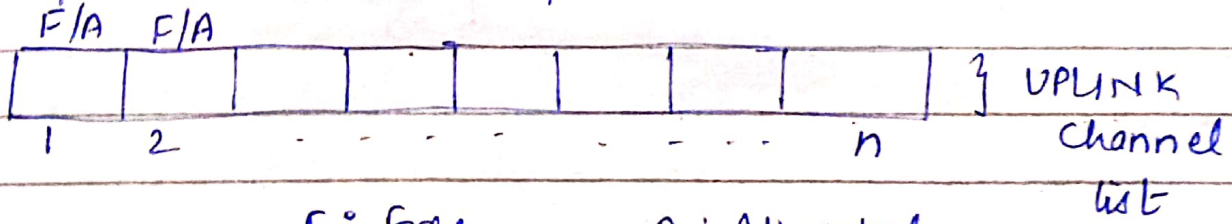
in Grant channel a message that X is allocated this uplink channel, Y is allocated that uplink channel.
Now, through paging, BS tells source & destination about the communication.

5- If no channel (control) can be allocated then BS tells through PAGING channel - N/W busy

6- When communication is done, free control channels added to FREE list.
When channel allocated, it is added to ALLOCATED list of channels.

→ implementation example



F: Free A: Allocated.

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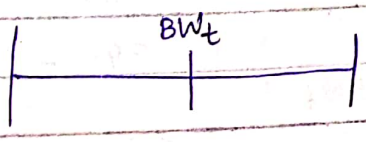
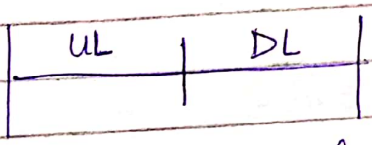
FDMA / FDD → duplexing (two sides)

↳ for mobile communication — 1 Generation

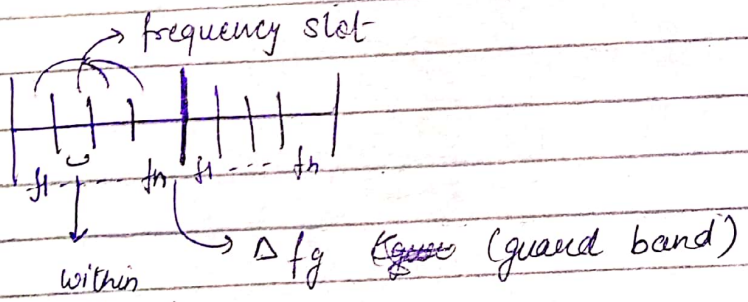


Channels will be created in frequency slot.



higher frequency me radiation zyada hota hai

$$BW_u = BW_d = \frac{BW_t}{2}$$



bhi guard band hota hai.

Voice channel → bigger frequency slot

Voice channel

Control channel ka frequency slot kitna hota hai

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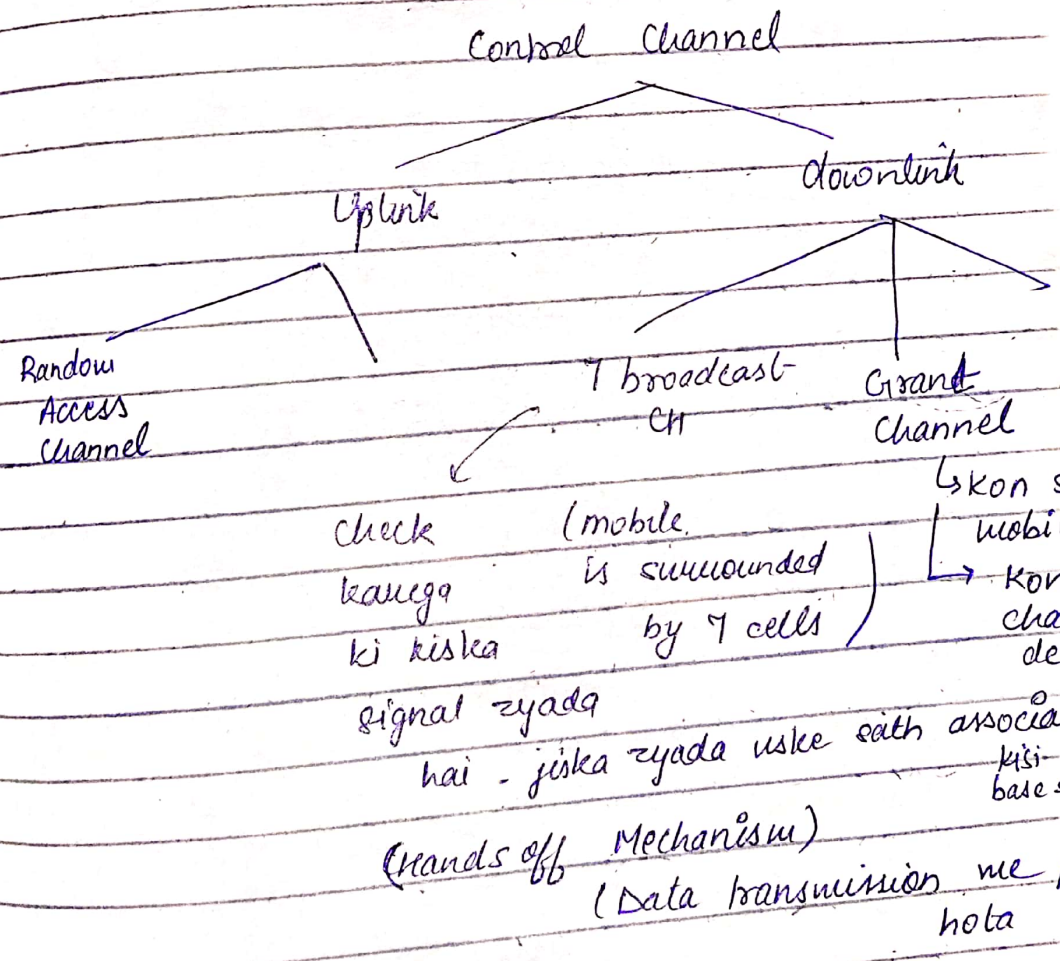
C

K me divide
kr dia

To total control channels C × k.
for uplink and downlink.

voice channel → slot
control channel → mini slot.

control frequency slots



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