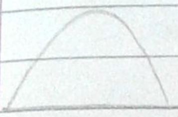
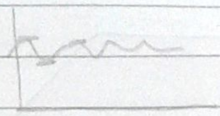
OFDM: Orthogonal freq. Division Multiplexer :



information signal



wireless channel

wireless channel → Higher data rate, bit duration less then ISI will ↑se becuz of reflection
→ less data rate,

* due to higher data rate in wireless channel
  - ISI ↑ses becuz of reflection
  - effect of noise (impulse)
  - channel LP → HF

even ↑ing SNR will not solve problem beyond certain limit.

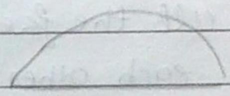
- wireless channel behave as LPF

1 MbPS → BPSK

BW = 1 MHz

T symbol = 1 μs

T_b = 1 μs

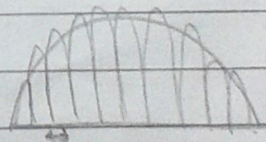


10 carriers

1 MbPS → BPSK

BW = 0.1 MHz

T symbol = 10 μsec



BW wasted

multiple carrier used instead of single carrier, we can remove ~~the~~ or overcome from the problem's of High data rate. But

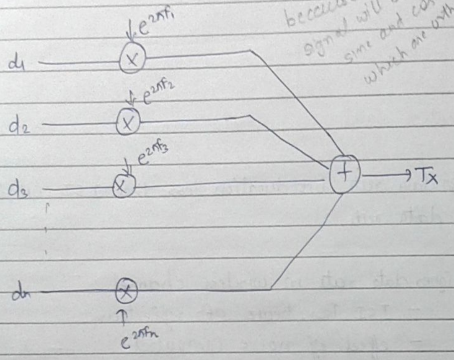
Hardware requirement is ↑ses because of carrier is ↑es

10 carriers → 10 Oscillators
→ 10 modulators

and also BW lost/waste is occur due to some space between two carrier is there.

So we keep the carrier orthogonal in multi carrier modulation $\longrightarrow$ "OFDM".

because all modulated signal will be in sine and cos which are orthogonal



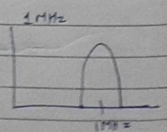
$$Tx = d_1 e^{2\pi f_1} + d_2 e^{2\pi f_2} + d_3 e^{2\pi f_3} + \_\_\_ - d_n e^{2\pi f_n}$$
$$= \sum_{i=1}^{N} d_i e^{2\pi f_i} \Rightarrow \text{IFFT}$$

- all the frequencies f_1, f_2 ... are orthogonal to each other. In this we required only IFFT; not 10 modulators, 10 oscillators for 10 carriers.

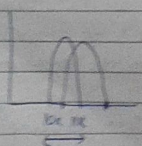
1 KbPS $\longrightarrow$ 1ms $= T_b$

$\frac{1}{2T_b}$

$= 0.5$ KHz

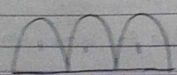


1KbPS



- BW lost is not occur in this
- BW utilization is there in OFDM
- even though spectrum's are overlapping, we can detect them without error because they are orthogonal.

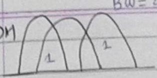
*



- BW lost ; BW = 3KHz
- ~~BW~~ spectrum is high

BW = 2KHz

OFDM



- BW lost is not occur
- BW utilization is there
- spectrum of carrier is less
- high data rate

20 MbPS - for 4G n/w, BW is less & data rate is high $\rightarrow$ OFDM

2 MbPS — 3G n/w, BW is high & data rate is less

10 KbPS $\longrightarrow$ BPSK

BW = 10 KHz

20 KHz

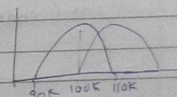
$f_c = 100$ KHz

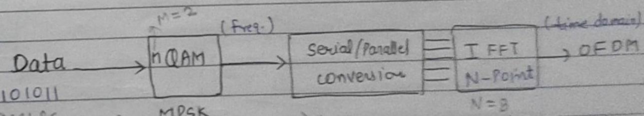
$f_1 - f_Q = \frac{1}{2T_b}$

$\hookrightarrow f_1 - f_c = 5$ KHz

~~100K~~

$\hookrightarrow$ 105K





16-Point FFT $\xrightarrow{QPSK}$ 16 carriers

8-Point FFT $\longrightarrow$ 8 carriers

1 OFDM symbol = $8 \times 2 = 16$ bit

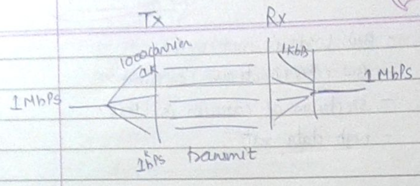
QPSK (1 symbol = 2 bits); N-point IFFT (N = 8); then 1 OFDM symbol having $2 \times 8 = 16$ bits

1 Mbps — 1000 1K carriers (S/P conversion)

by using OFDM

easily transform

P/S $\longrightarrow$ 1 MbPS



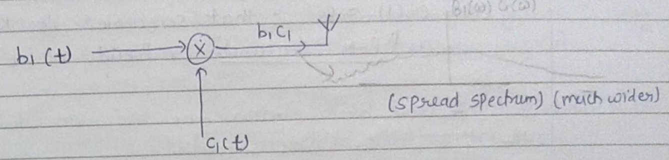
① FDM (freq. division multiplexing) sinerio-1

② TDM (sinerio-2

③ CDM (code division multiplexer) sinerio-3
(orthogonal to each other)
(totally different languages)

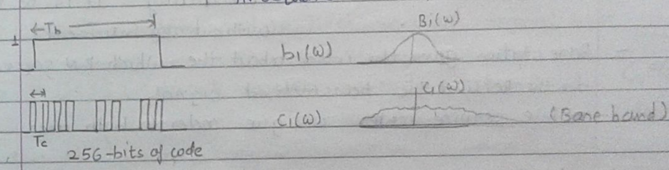
Date 5-Aug

CDMA: Code Division Multiplexer



(spread spectrum) (much wider)

- code
- PN sequence



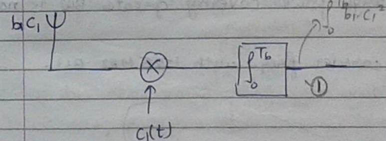
(b_1) $b_1(\omega)$

(c_1) $c_1(\omega)$ (Base band)

256-bits of code

$$b_1(t) \cdot c_1(t) \longleftrightarrow B_1(\omega) * C_1(\omega)$$

↳ How we demodulate our b_1 from $b_1 c_1$!



$\int_0^{T_b} b_1 \cdot c_1^2 = b_1 \int_0^{T_b} c_1 \approx b_1 \cdot 1$

- correlate with $c_1(t)$ to get back data $b_1(t)$.
- if we are using different channel freq. (carrier) for diff. device so Bandwidth requirement is very high, which is not possible practically.
  So we are using same channel freq. for diff devices.

at point ①:

$$\int_0^{T_b} b_1 c_1^2 + \int_0^{T_b} b_2 \cancel{c_2 c_1}^{0} + \int_0^{T_b} b_n \cancel{c_n c_1}^{0}.$$

$\cong b_1$ (c_1 & c_2 are orthogonal)

Pseudo noise, random signal, wider spectrum

Date ______
Page ______

- We have to generate the sequence in such a way that C_i & $C_n(t)$ are orthogonal to each other.

  $\int C_i(t) \cdot C_n(t) = 0$; that sequence is known as "P-N sequence" or Pseudo noise

- (Mobile switching center) MSC and base station gives the knowledge about the C_1 & C_2 ... C_n code sequence.

- PN sequence = 2^{256} ; theoretically it is ∞ no. (without any interference)

- Base station gives the idea about the which P-N sequence gives for the received the transmitted signal.

(mobile user) ("user")

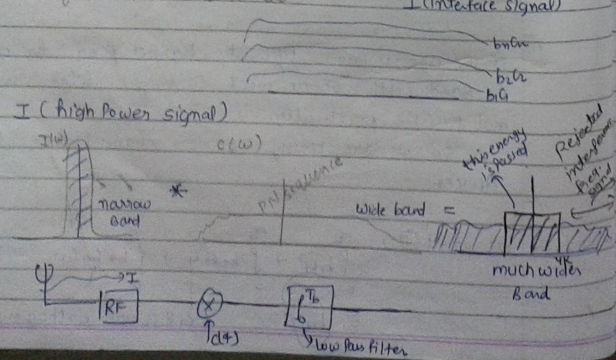
- mobile service center will give codes to both user

⇒ Main problem is noise & interference
  i) Secure signal
  ii) No interface by any jammer

To send extremely high power covering greater BW is not possible.

Eg: 900 MHz carrier freq. with 1.25 MHz BW.

So, transmitting high power signal with wide BW is not possible so this interfering signal is sent at a certain freq. So it is circulated one by one in the wide BW.



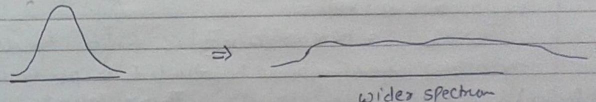
PN (Pseudo noise → random signal for third person, known by the Tx & Rx)

Date ______
Page ______

interference is made by wide band by the convolution and then passing through the low pass filter, some interference energy is used, and some energy will gone, which is more significant or we rejected the interference freq. signal.

⇒ 4G (SDM) in which channel is used without any interference by the more Tx. Because antenna is designed in such a way that only particular Tx is transmitted and receiver, received signal back.

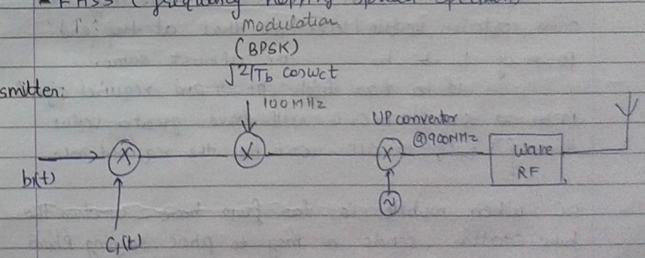
⇒ - DSSS (discrete sequence spread spectrum)



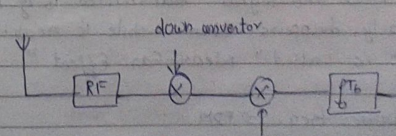
Because CDMA technique spread the spectrum with the help of Pseudo sequence.

- FHSS (frequency hopping spread spectrum)

Transmitter:



Receiver:



Scanned by CamScanner

CDMA: same carrier freq. / 1.25 MHz

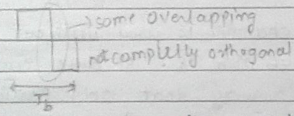
GSM: diff. carrier freq. | 200 kHz (FDM & TDM) both are used in GSM.

one carrier freq. given the 8 users by using TDM

$\Rightarrow$ In practically PN sequence is finite ?

In reality c_1 & c_2 — c_n are not completly orthogonal

$$\underbrace{\int b_1 c_1^2}_{10} + \int b_2 \underset{\substack{\downarrow \\ \text{not zero} \\ 0.1}}{c_2 c_1} + \int b_3 \underset{\substack{\downarrow \\ 0.1}}{c_3 c_1} + \cdots$$



then we get signal + noise (Interference)

so I/P signal power > Interference

$10 > (0.1 \times 99)$

P-N sequence is finite, for detect the actual signal, should be limited as per requirement

(constant Power)

Near-far Effect: every users

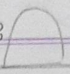
The power of b_1, b_2, b_3, — should have less than some certain value / level so that at the end power of b_1, b_2, b_3 — are almost same.

if b_2 has high power and required signal is b_1 $\Rightarrow$ so $\int_0^{T_b} b_1 c_2 c_1$ will have greater value than $\int_0^{T_b} b_1 c_1^2$ $\Rightarrow$ O/P won't be the required one.

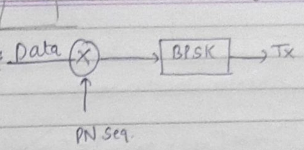
so, when mobile is far from base-station then base-station sends a msg to phone saying Phone far from it. Then the signal transmitted is of high power. Similarly, happens when mobile is near. This effect is called "Near-Far Effect."

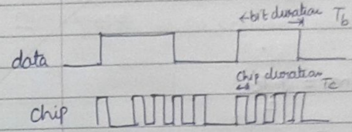
GSM:
- Diff^r carrier freq. $\rightarrow$ FDM
- BW given to each freq. is 100 kHz.
- TDM is also used in GSM $\Rightarrow$ A certain no. of users can use same BW and carrier freq.

Date 11-Aug

CDMA:  / DSSS technique

transmitter:

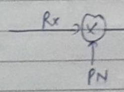




chip rate > Data rate

- XNOR operation is there between data & code

Receiver:



- at receiver side our information signal is despreaded and noise is spreaded.

- all PN sequence should be orthogonal to each other.
- Bandwidth is wider in CDMA, but we used this for multiple user.
- Problem: maintain the synchronization

$\Rightarrow$ $E_b \to$ bit energy

T_b, T_c

$J \to$ interference Power

$r(t) \to$ DSSS Rx $\to$ noise [$r(t) \times$ PN seq] = [spread noise, despread signal]

SNRI $\quad$ SNRo

(E_b/T_b) / J

Variance of interference $= \frac{J\,T_c}{2}$

$$SNR_o = \frac{E_b}{J T_c/2}$$

$$SNR)_o = \frac{2E_b}{T_b\, J\, T_c} \cdot T_b$$

$$\boxed{SNR)_o = 2 \times (SNR)_I \cdot \frac{T_b}{T_c}}$$

$\because \frac{T_b}{T_c} > 1$ (always)

if PN seq. length is T_{sec}, bit duration is T_{sec}, then Bit duration is T_{sec}

So, $\frac{T_b}{T_c} = N \to$ (length of PN sequence)

- By ↑ing the value of N (PN-seq), then SNR)o will increase that means signal power is more, interference is less.

- $$SNR)_{o\,dB} = 10\log 2 + SNR)_{I\,dB} + 10\log N$$
  $$= 3 + SNR)_{I\,dB} + P.G. \quad \text{Processing Gain}$$

processing gain $= 10 \log\left(\frac{T_b}{T_c}\right)$

- DSSS will not protect our signal from the AWGN noise because AWGN having wider spectrum

- 3 types of PN sequence used in CDMA $\to$ short

- if $T_b/T_c = 100$
  then 1 bit error will occur when 51 chip bit detect wrongly.

  bit

  $\to$ chip $\quad$ (100 chip = 1 bit data)

  so $\quad P_e = \frac{1}{2}\,\text{erf}\left(\sqrt{\frac{E_b}{J T_c}}\right)$ $\quad \left(\frac{N_0}{2} = \frac{J T_c}{2}\right)$

- Jamming (High freq. component added, so we can't detect our original signal

Date 17-Aug

Jamming Margin:

jamming margin is the parameter which would decide how much a receiver would provide protection against jamming.

Q

$$\frac{E_b}{N_0} = \frac{P \cdot T_b}{J T_c}$$

jamming Power ⟵ $\frac{J}{P} = \frac{N_0 T_b}{T_c E_b} = \frac{(T_b/T_c)}{(E_b/N_0)}$
Power of signal ⟵

Ex: spread spectrum system has the following factors:
$T_b = 4.093$ ms ; $T_c = 1\mu s$; probability of error acceptable $P_e = 0.387 \times 10^{-5}$; $E_b/N_0 = 10$
Find out the processing gain & jamming margin

Sol:

$$\text{processing gain} = 10 \log\left(\frac{T_b}{T_c}\right)$$

$$= 10 \log\left(\frac{4.093 \times 10^{-3}}{1 \times 10^{-6}}\right)$$

$$= 36.12 \text{ dB}$$

gain $= T_b/T_c = 4093$ Ans.

$$\text{jamming margin} = \frac{(T_b/T_c)}{(E_b/N_0)} = \frac{4093}{10} = 409.3$$

In dB $= 10\log(T_b/T_c) - 10\log(E_b/N_0)$

$= 36.12 - 10$

$= 26.12$ dB Ans.

Q

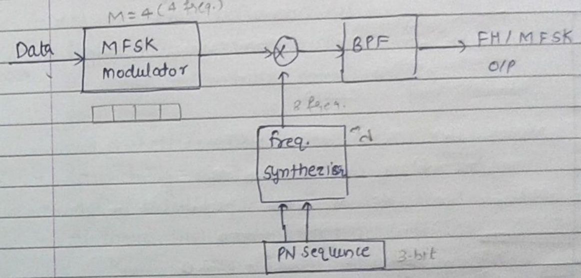
— $\frac{J}{P} = \frac{4095}{10} = 409.5$, to jam a signal atleast ($409.5 \times$ signal power) jammer signal power is required.

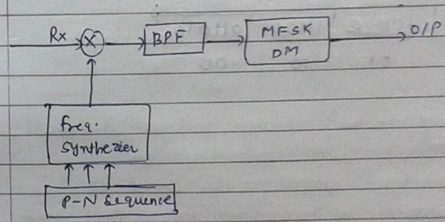
FHSS (freq. hopping spread spectrum):

hoping ⟶ changing the frequency

there are two types of freq. hoping:

(i) Slow FHSS (ii) fast FHSS



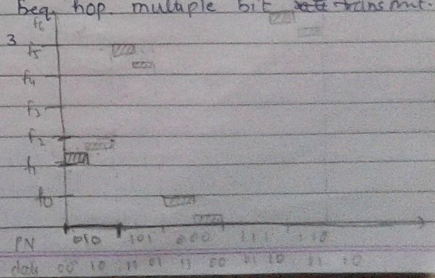


(i) Slow FHSS:

↳ freq. hoping slower than data rate
↳ data rate is faster the hopping rate.
↳ in single freq. hop multiple bit ~~rate~~ ~~transmit~~.

length of PN seq / hop = 3

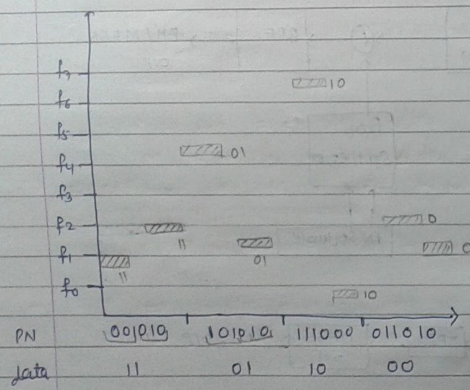
M = 4



— Application: Bluetooth

(ii) Fast FHSS:

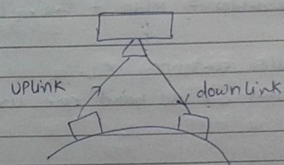
↳ freq. faster then data rate
↳ data rate is slower the hopping rate
↳ single bit Tx over multiple freq.



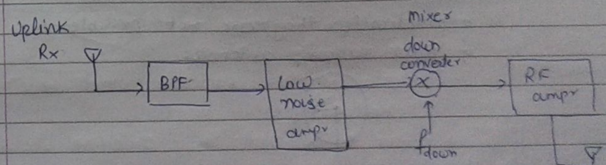
SATELLITE COMMUNICATION

Date 22-Aug

- line of sight communication
- No problem by reflected signals as delay is very less.
- its an AGWN noise channel
- higher the antenna ⇒ larger distance covered in other comm^n s/s while in satellite comm^n area covered by satellites are very large.
  3 satellites can cover the whole earth.
- launching cost of satellites is high.
- age of satellite is 2-15 yrs acc. to amount of fuel present in it.
- distance b/w earth & satellite is large ⇒ delay occurs (ms)

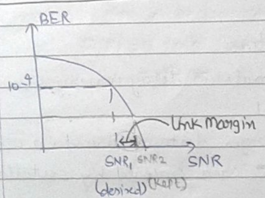


- Uplink & downlink comm^n frequencies are different.
  $f_{(uplink)} > f_{(downlink)}$
  bcoz power availability at satellite is limited while base-station can provide high power to signal and as $f \propto$ power.



- satellite comm^n depends on weather. So we keep a margin to get signal properly.

Link Margin :



for transmission of signal in channel having low parameters and when channel parameters vary so SNR is kept higher than what is needed.

SNR(chossen) = M SNR(required)

M, is mostly in 3 or 6 dB

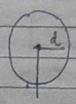
⇒ SNRchossen in 3 dB or 6 dB higher than SNR(req.)

SNR choosen (dB) = MdB + SNR req. (dB)

- f ↑ ⇒ smaller antennas req.
  So c band or KU band are used.

ANTENNA :

- converts electrical signal to electro-magnetic waves or vice-versa.
- Isotropic Antenna: → radiates signal in all direction in uniform / equal power.
  - practically they are not possible.
  - point sauare antennas



power density for isotropic antennas

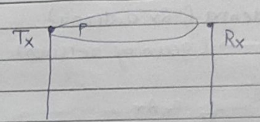
$$= \frac{P}{4\pi d^2}$$

P → Power
d → distance

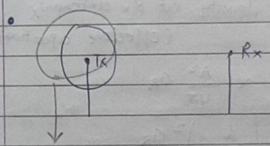
(spherical cordinates are considered here)

- d↑ ⇒ Power density ↓ses ⇒ signal power ↓ses and vice-versa.

- Directive antennas: → radiates signal in a single direction

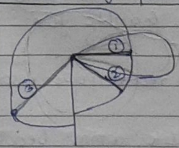


- Power density in single direction is higher in directive antennas than isotropic antennas.



Power is wasted in isotropic antenna when we req to transmit in single direction.

* **Directivity Gain:** = $\frac{\text{Radiation intensity at } (\theta, \phi)}{\text{Radiation intensity of isotropic source}}$



G(1) → max
G(2) → less
G(3) = 0

directivity of antenna depends on (θ, ϕ) of direction in which it is Tx.

max of directivity gain is ⟶ directivity.

* **EIRP** (effective isotropic radiated Power) : at Tx antenna
equivalent

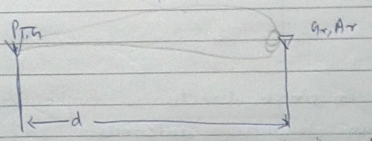
it is amount of power that theoritical isotropic antenna would emit to produce peak power density observed in direction of the max. antenna power gain.

EIRP = (total Power transmitted) (total Gain)

$= P_T G_T$

* Effective apparture of antenna (Rx antenna)

$A = \frac{\lambda^2}{4\pi} \cdot G_R \longrightarrow$ (gain of receiver)



(received power) P_R = (Power density at Rx antenna) x (effective aperture)

Friss Free space eqn :

$$= \frac{EIRP}{4\pi d^2} \times \frac{\lambda^2}{4\pi} G_R$$

$$= P_T G_T \left(\frac{\lambda}{4\pi d}\right)^2 G_R$$

$P_T \rightarrow$ can't be increased as not feasible

$G_T \rightarrow$ Can be ↑sed } should be high

$G_R \rightarrow$ Can be ↑sed

$\lambda \rightarrow$ should be high but due to this frequency reduces, which is not feasible for transmission.

$d \rightarrow$ larger the distance ⇒ receive power ↓ses exponentially

∴ bcoz of this satellite commn becomes challenging.

Thus, size of Tx and Rx antenna should be large.

DCOM

Date 24-Aug

path loss $= \frac{P_t}{P_R}$ $\rightarrow$ (transmitted Power) $\rightarrow$ (received Power)

P_R = Power density x EA

$$= \frac{EIRP}{4\pi d^2} \times \frac{\lambda^2}{4\pi} \times G_R$$

$$P_R = P_T \cdot G_T G_R \left(\frac{\lambda}{4\pi d}\right)^2$$

$$\frac{P_R}{P_T} = G_T G_R \left(\frac{\lambda}{4\pi d}\right)^2$$

So; path loss $= 10 \log\left(\frac{4\pi d}{\lambda}\right)^2 + 10 \log\left(\frac{1}{G_R G_T}\right)$

Noise figure:

$$F = \frac{\text{i/P SNR}}{\text{o/P SNR}}$$

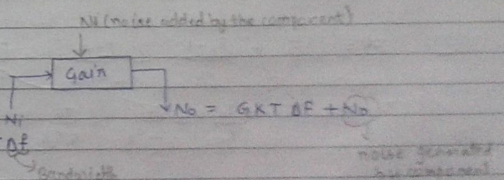
$\rightarrow$ i/P signal power

$\rightarrow$ i/P noise power

$$= \frac{S_i / N_i}{S_o / N_o} = \frac{N_o}{N_i (S_o/S_i)}$$

$$= \frac{N_o}{N_i \cdot G}$$ $\rightarrow$ (Gain = o/P Power / i/P Power)

Noise temperature:



$N_i = K T \Delta f$ $\rightarrow$ Bandwidth

$N_d = G K T_e \Delta f$ $\rightarrow$ noise equivalent temp

– all tempr which are generated, they are thermal noise

K → boltzman constant

T → temp (outside environment) Noise

T_e → equivalent noise by component (temp)

So; $N_o = GN_i + N_d$

$= GK\Delta f T + GK T_e \Delta f$

$N_o = GK\Delta f\,(T + T_e) \Rightarrow \frac{N_o}{GN_i} = (T + T_e)$

- noise figure $F = \frac{N_o}{N_i G}$

$\cancel{F = T + T_e}$

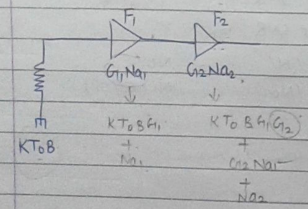
$= \frac{\text{total o/p noise power}}{\text{o/p noise generated due to i/p}}$

$= \frac{N_o}{N_o - N_d}$

$$\boxed{F = \frac{T + T_e}{T}}$$

$\therefore T_e = T(F-1)$

*



$F = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 G_2} + \frac{F_4 - 1}{G_1 G_2 G_3} + \ldots \rightarrow$ cascade connection

$T_e = T_1 + \frac{T_2}{G_1} + \frac{T_3}{G_1 G_2} + \frac{T_4}{G_1 G_2 G_3}$

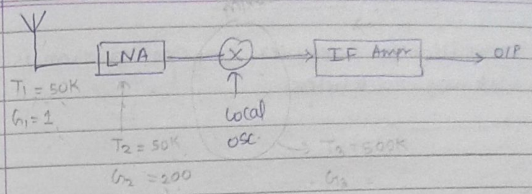
Example 3: $T_{antenna} = 50K$; $T_{RF} = 50K$; $T_{mixer} = 500K$

$T_{IF} = 1000K$; Gain RF ampr = 200

there is earth terminal device calculate

i) Noise tempr ii) Noise figure

Sol^n



$T_{eq} = T_{ant} + \frac{T_{RF}}{G_1} + \frac{T_{mixer}}{G_1 G_2} + \frac{T_{IF}}{G_1 G_2}$

$= 50 + \frac{50}{1} + \frac{500}{200} + \frac{1000}{200}$

$= 107.5$ **Ans.**

Link Budget Analysis:

EIRP = 46.5 dBW

G/T = 24.7 dB/K

free space loss = −206 dB

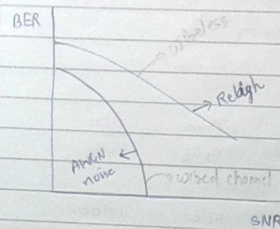
C/No = 93.8 dB-Hz (carrier to noise ratio)

G_R (?)

Date 29-Aug

Wireless Mobile Communication

- transmitter or receiver, any one of them is not stationary → wireless



- for wireless, its performance is very bad and its difficu[lt] to implement because every time channel is changed du[e] to moving Tx or Rx.

There are some elements which are required in mobile communicat[ion]

Base station: mobile towers are known as base station. (BTS)

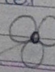
Mobile station: mobile headset (MS)

Base station controller: (BSC)

Main s/w ~~controller~~ center: (MSC)

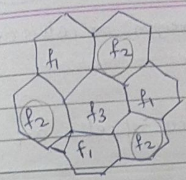
Wireless (Mobile)	Wired (Landline)
- BW:- 15 to 20 K bPS	- BW:- 64 KbPS
- channel is not always availabe. (we have to sent the request for using the channel if we have enough balance then and only then we used it)	- channel is always available

* theoritically shape of cell (area or region which is covered by tower) is circle, but its not possible practically. ; so practically it will be hexagona[l]



To cover the whole area, shape

Date
Page



we are using different frequencies, because if we uses same then interference will occur.

if we are using only single frequency:

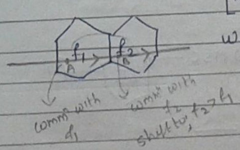
- High power radiation (which are harmful for human)
- physically not efficient (if we are using 100 or 200 users over a same freq. BW is also very high)

- places away from base station will not be able to commⁿ as power of signal ↓ses and reflecti on ↑ses ⇒ if 1 freq. is used.

* in rural area, then area of cells are large, because there user are less as compared to Urban area's in Urban area, area of cells is very smalls because poppulatio[n] is very high.

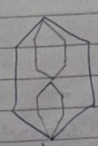
- if three freq. is used then the distance b/w the region using same freq. is less so interference [may occur. so no. of freq. used is ↑sed.]

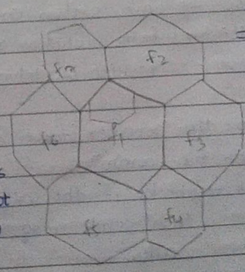
handoff:



we communicate with f1, only then when strength of freq. f1 signal is high compared to f2 signal.

Cell spliting:

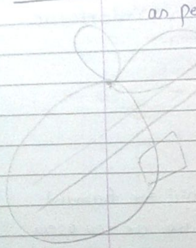




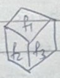
⇒ here no of users in f1 region has ↑sed so it is been splitted using other freq.

- cell spliting is used when no. of users in an area ↑ses which is not been able to be controlled by a tower.
- for these portable towers are used.

Sectioning: in this we are divided the region ~~as~~ cell's area as per the requirements.

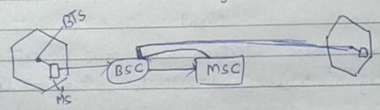


- By sectioning, area of cells are different
in mobile commⁿ we have three stations:



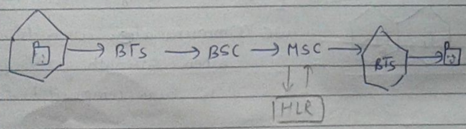
used when no. of users in particular regions differ highly.

⇒



control channel ⟶ its requesting for the using the channel.
voice channel ⟶ its provided by the ~~MS~~ channel.

Path of commⁿ of mobile:



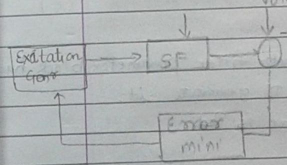
BTS → base station
BSC → base station control
HLR → home location register
MSC → mobill switching center

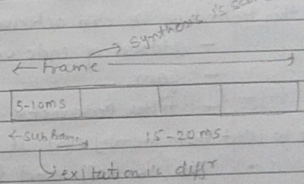
- Once, the receiver takes the call → channel is located' given for commⁿ.
- HLR → checks if the caller has balance or not and then sends msg. to allow or not to allow.
- MSC → provides path and other parameters req. to know about where is the receiver's mobile.

Source coding of speech in wireless channel:

Linear predictive coding:
→ synthesis filter (previous samples (predict the actual signal)
→ excitation generator
→ error minimization

④ Multi excited Technique:





(filter and excitation parameters are transferred, not the speech)

- speech signal is transferred / transmitted in form of synthesis signal.
This is done through (linear predictive coding)
- 3 components through which prediction is done:
(i) synthesis (ii) Excitation (iii) Error minimization

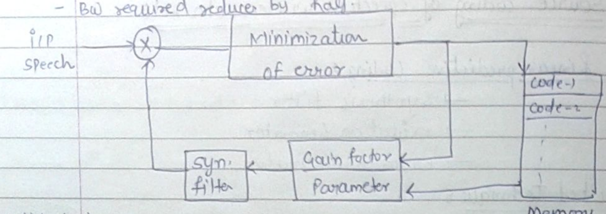
Synthesis filter ⟶ generates synthetic speech by linear prediction coding.

- Excitation parameters change from subframe to subframe
- synthesize filter parameters change from frame to frame.
- synthesize filter has 15-16 ~~previous~~ samples of speech through which it predicts previous the current signal.
current voice signal and synthesis filter signal (Predicted) is compared and sent to error minimization block then to excitation generator ⟶ here excitation parameters changes which is sent to SF and cycle goes on.

Rx signal → Excitation Genʳ → Synthesis filter → synthetic O/P speech

B code excited LPC (linear predicted coding):

- code of excitation parameter is stored in memory.
- BW required reduces by half.



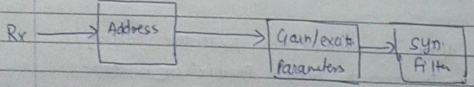
in this technique we can acheive:

- address of code vector
- gain
- filter parameter. Here, Gain factor/filter parameter block has just to select from memory and it does not has to generate it.

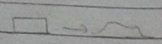
• BW is half and hardware size is ↑ed.

!

- in this system hardware size ↑ses.



Problem of wireless commⁿ:

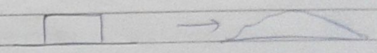
1. fading (Delay spread) 
2. Scattering
3. Dopler shift

A - Excitation genʳ provides the info of when and of what magnitude pulse should be generated by SF.

- In wired channel, signal can be sent by sampling at 64 KbPs → in wireless, for this sampling rate spectrum min to 2KbPs, 4 KbPs, 8KbPs.
  ⇒ signal Rx would be exact ⇒ LPC is used

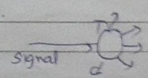
(1) **fading:**

Signal strength is fluctuation bcuz of ISI, reflection etc.

- All ISI, reflection noise etc. add up → cause fading.
- indoor and outdoor fading varies as no. of reflection and delay varies
- Delay spread 

(2) **Scattering:**

- found in satellite commⁿ, micro-wave commⁿ and not is GSM.
- Higherᵗ then object → then signal can pass/Penetrate through it.
- when signal collides with a small then energy of signal scatters.



(3) **Dopler shift / Dopler effects**

- if Tx or Rx is moving then received by Rx would be different from the Tx freq.
- Depends on direction of motion & velocity of motion.
- velocity ↑ses → Dopler effect ↑ses.

GSM :

- GMSK modulation is used.
- Downlink freq. > than uplink freq. as
  for uplink, mobiles are the source
  downlink, base stations are the source.
- 900 MHz and 1800 MHz ~~used for uplink~~ are two Bands
  - 890 to 915 MHz → Uplink
  - 935 to 960 MHz → downlink

- 25 MHz band is divided into 125 diff^r channels using FDMA.
  1 channel is of 200KHz → and then through TDMA each channel is divided into 8 parts, i.e., 8 diff^r signals can be transmitted.

• 25 MHZ

$\downarrow$ FDMA

125 channels of 20CKHz each

$\downarrow$ TDMA

each channel divided into 8 parts / users
(of 25KHz BW available for each user)

Voice → 13.4 KHZ

(1) fading :
Signal strength in fluctuation ...

SMVS
Page No.
Date : / /

IS95 : (CDMA)

- 20 channels are present
- each channel BW is 1250 KHz
- used in CDMA
- 20 - 35 parts / User per channel with 62.5 KHz BW available for each user
- QPSK modulation used.
- By using rake receiver, multipath

CDMA + TDM ⟶ UMTS (3G → mobile phone)

Date 1 - Sep
Page

<u>Multiple Acess technique</u>: there are following techniques:

1. TDMA (Simulatenouly acess is not possible)
2. FDMA
3. CDMA
4. SDMA

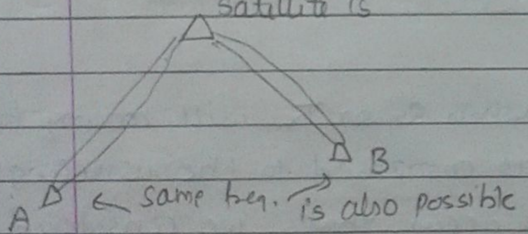
- 10 user
  100KHZ

for TDMA ⟶ 100×10 KHz BW is required

for FDMA ⟶ 100×10 KHz BW " " (carriers are different at diff freq.

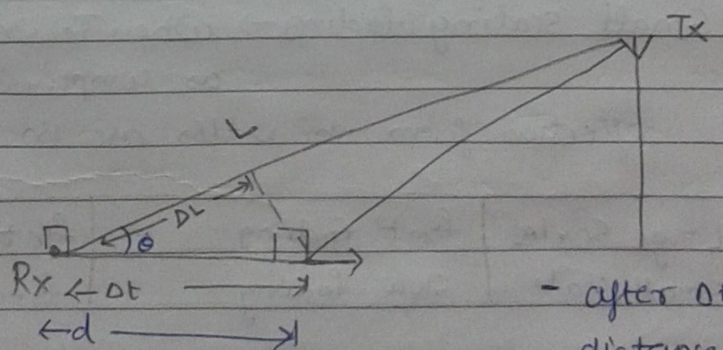
for CDMA ⟶ 10 Chips are required for 1 bit transmit
10 orthogonal diffr codes are required
So BW is also ↑ses.

<u>space division multiplexing</u> SDMA:



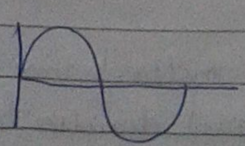
users are separated by the space
multiple users can use same
satellite s/s for communication.

<u>Dopler shift</u>: Dopler shift is possible when any one of Tx or Rx is moving.



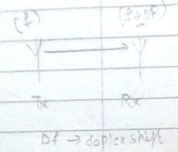
$\Delta L = d\cos\theta$ —— (1)

- after Δt time, distance between Tx and Rx is less by the ΔL.



$\lambda \longrightarrow 2\pi$ (length in complete one cycle)

$\Delta L \longrightarrow \boxed{\Delta\phi = \frac{2\pi}{\lambda} \times \Delta L}$ (2) (change is phase) change in frequency : $\Delta f = \frac{1}{2\pi} \frac{\Delta \phi}{\Delta t}$



$= \frac{1}{2\pi} \times \frac{2\pi}{\lambda} \Delta l \cdot \frac{1}{\Delta t}$

$= \frac{d \cos\theta}{\lambda \Delta t}$

$\Delta f \rightarrow$ dopler shift

$$\boxed{\Delta f = \frac{v}{\lambda} \cos\theta}$$

Ex:- $f \rightarrow 900\,MHz$; $v = 200\,km/H$; what will be the dopler shift ?

Sol: $\Delta f = \frac{v}{c/f} \cos\theta$ $\quad \theta = 0°$

$= \frac{200 \times 10^3 / H}{900 \times 10^6 / sec}$ =

fading : (a) large scaling fading → when Rx or Tx will moving fast as compared to the wavelength then what will affect is occur, that's we considered in large scaling fading. scattering is ocur in Large scale fading.

(b) Small scaling fading → when Tx or Rx will moving slow as compared to wavelength. reflection from the walls are in Small scaling fading.

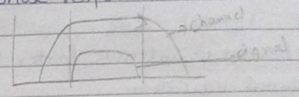
Large Scale	fast fading	flat flading
Small scale	slow fading	freq. Selective fading

coherence Bandwidth : measure of transmission BW across ~~for~~ ~~which~~ for which signal distortion across ~~occures~~ ~~across~~ channel becomes noticable.

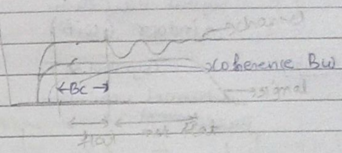
Cohorence time : measure of transmitted ~~time across~~ ~~for which signal~~ signal duration for which disortion across channel is noticable is called coh.

(c) flat channel : whose response is flat

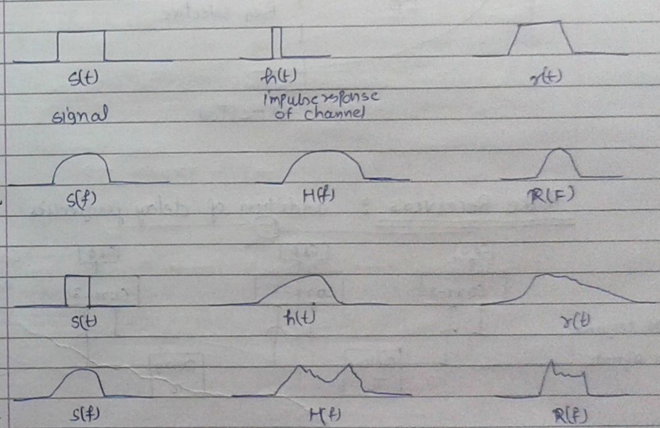
$B_c > B_{signal}$ (fading)



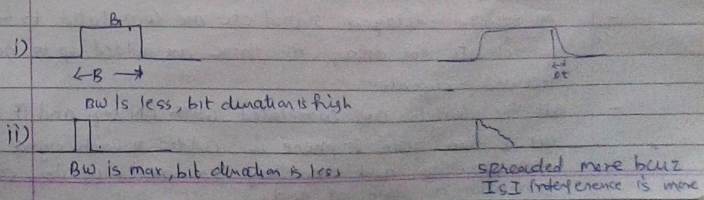
(d) freq. selective channel:



- coherence BW (B_c) < signal BW (B_s) [for freq. selective



- By seen this we can say that flat fading is better



Date 7-Sep

(e) fast fading :

$T_{symbol} < T_c$

channel variation is faster than the ~~ch~~ baseband signal variation.

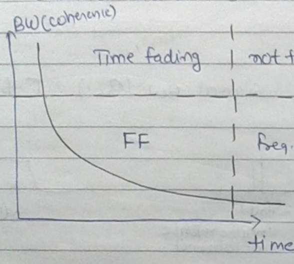
- indoor (wifi)

(f) Slow fading :

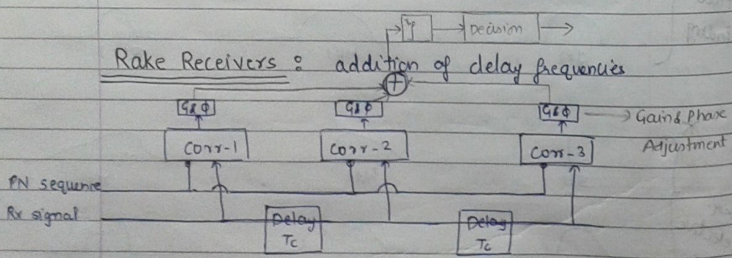
$T_{symbol} > T_c$

channel variation is less than the signal variation

- outdoor



Rake Receivers : addition of delay frequencies



adjust of Gain & phase of correlator before summing then.

- chip duration is small
- Rake receivers are used in CDMA.
- All reflected, delayed signal etc are correlated to removel compensate the delay. All these are added up to get received signal.
- all the signals are correlated with PN seq. and if we get 1 then gain & phase is added to each signal from each correlator and then they are added up i.e., constructive correlation is done at end.

In GSM : Uplink freq. < down link freq.

Satellite : down link < Up link freq.

Date ____ Page ____

- In GSM : (mobile wireless commⁿ)

890 to 915 MHz & 935 to 960 MHz (935-960) & Tx/Rx freq. spacing = 45 MHz

UP Link / Downlink

20MHz

Tx/Rx time slot spacing = 3 time slots

200 KHz → 125 channels

TDMA

125 channels

allotted channel BW for: 8 TDMA slots (200/8 = 25 freq. range)

Users : 125 × 8 = 1000 users

- if 25 Users

$25 \times 60 \times 24 = 1500 \times 24$ /Rs-

(60 → min., 24 → hours)

= 36000Rs/- and fully busy n/w

↓

50% (12 hours)

↓

18,000 Rs/-

	GSM	IS95 (CDMA)
channel :	125	20
BW :	200KHz	1250 KHz
slots :	8	20 to 35
BW / Users :	$\frac{200}{8} = 25$	BW/Users : $\frac{1250}{20} = 62.5$
	GMSK	QPSK

- all the components of Rx signal are treated individually.
- chip duration should be small because when symbol duration is small, ISI would be present reflected / signal / components reach Rx with less delay compared to los (line of sight) signal.

* GSM s/s Architecture
  - 26 bits training is used by equalizer.
  - signal Processing in GSM - channel coding : error correcting cap

Date 8-sep.

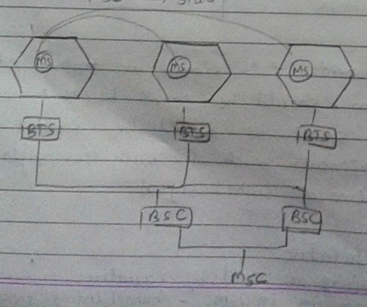
Signal Processing in GSM :

Speech ↓		Speech ↑
Digitizing and Source coding ↓		Source Decoding ↑
channel coding ↓		channel decoding ↑
Interleaving (data is set in such a way that only known by Rx) ↓		De-interleaving ↑
Burst formating ↓		Burst formating ↑
Ciphering ↓	Radio	De-ciphering ↑
modulation →	Channel →	Demodulation

we hack this for 3 sec. it is not secure type of commn.

*

BTS → MS →
BSC → district
MSC → state



Date 19-Sep

in CDMA ⌈ Modulation (Orthogonal BPSK)
⌊→ Spreaded (QPSK)

CDMA features:
- Power control (nearer to cell Power is more, so equalize power from all users)
- reduced interference
- Universal frequency reuse
- Reduce interference
- N/W capacity – higher capacity than GSM, i.e. more no of calls may be made by reducing the quality.

UMTS : Universal Mobile telecommunication S/S

- ~~FDM + CDMA technique is used~~
- UMTS uses wideband - code division multiple access (W-CDMA)
- freq. division duplex (FDD) } By using this we can manage the uplink & downlink freq & time
- time (TDD) } By TDD we can adjust the uplink & downlink time.
- modulation is done with QPSK

in CDMA uplink & downlink freq. are fixed, which we can't change.

WCDMA FDD :
- channel BW = 5 MHz
- frame length = 10 ms

⇒ 3G, 4, H+
- HSDPA (High speed downlink packet Access)
  - Use 16 QAM to reach 10 MBPS
- HSPA+ (High speed Packet Access)
  - 64 QAM 21 MbPS