Vidyavardhini's College of Engineering & Technology

Department of Electronics & Telecommunication Engineering

Experiment No. - 1

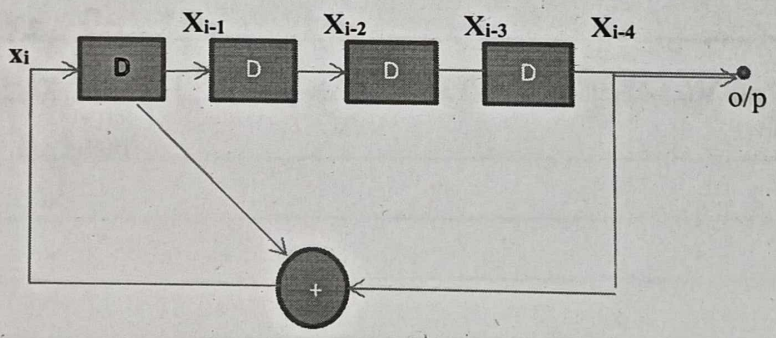
AIM: **To generate PN Sequence of length 2^n-1 using n-bit linear feedback shift register and verify it with properties of PN Sequence.**

Theory:

A Pseudo –noise (PN) sequence is defined as a coded sequence of 1s and 0s with certain auto correlation properties. It is deterministic, has very low correction between shifted versions of the sequence have very low correction between any two sequences. The PN sequence is usually generated using sequential logic circuit. A feedback shift register, where the binary sequences are shifted through the shifted registers in response to clock pulses and the output of the various stages are combined (logically) and feedback as input to the first stage. When the feedback logic circuit consists of EXOR gate, the shift register is called linear PN sequence generator. There are 2^m - 1 non-zero states for an m stage feedback register. The period of PN sequence produced by a linear m-stage shift register cannot exceeds $2^m - 1$ symbol. A sequence of period 2^m - 1 generated by a linear feedback register is called a maximum length (ML) sequence. In DSSS, PN sequence is used to convert low bandwidth signal to high bandwidth signals. Primitive polynomial for n = 4 is

$$f(x) = 1 + x + x^4$$

Diagram:



Answer the following questions

1. What are the properties of PN sequence?
2. What are the applications of PN sequence?

Result Analysis and conclusion

PN Sequence generator of 4 bit using LFSR was generated with length as 15 bits. After 15 ~~rounds of~~ CLK the values were repeating and All properties such as orthogonal balance run length, correlation was successfully verified in MATLAB

2. What are the applications of PN Sequence?

→ PN Sequences have several important applications:-

1) Spread Spectrum Communication:- PN Sequence are used to spread the bandwidth of signals improving resistance to interference jamming & interception.

2) Code division multiple access (CDMA):- PN Sequence end CDMA network by allowing multiple users to transmit data over a single communication channel.

3) Cryptography:- The random like properties of PN sequences makes them helpful for encryption & secure communication.

4) Radar and Sonar System:- PN Sequences are used for target detect and ranging in radar and sonar applications.

5) System Identification:- PN Sequences are used in control engineering for system identification & testing.

6) Scrambling:- PN Sequences are used to scramble data for applications like Pay TV.

7) Synchronization:- PN Sequence enable synchronization in communication system.

1. What are the properties of PN Sequence?

→ i) Orthogonality - No of Zero's & one's should be equal after XORing

ii) Correlation - Autocorrelation = 1

Crosscorrelation = 0

iii) Balance property - No of one should be one more than 0.

i.e (15 bits - 8 ones

- Zeros)

iv) Runlength property - a) Consecutive 1 = n

b) Consecutive 0 = n-1

b) 2^{k-1} times, n - k-1 bits

where k = 1, 2, 3, - - - n

(1) k = 1, 2^{1-1} times, n-k-1 bits of 1's & 0's

= 1 time, 2 bits

(2) k = 2, 2^{2-1} times, n-k-1 bit of 1's & 0's

2^{2-1} times, 4 - 2 - 1 bits of 1's & 0's

= 2 times, 1 bit.

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Experiment No. - 02

AIM **To analyze the effect of cluster size on system capacity.**

Theory

The major attributes of cellular communication systems are large coverage area, effective spectrum utilization and enhanced system capacity. The total number of channels available in a cellular system is finite because of limited RF spectrum allocation .The capacity of a cellular system is defined by the total number of RF channel available .To increase the capacity available RF channels are reused at some distance, by forming the cluster of size N=3, 4, 7.

- Suppose cellular system is having **K** duplex channel
- Cluster of size N=3,4,7
- Number of channels per cell **J =K / N**
- To cover the given area cluster is repeated M times
- System capacity = M*K

Problem

A 40 MHz frequency spectrum is allocated to a wireless FDD cellular system which uses 30KHz simplex Channel to provide full duplex channel. Calculates number of channels per cell if system uses cluster size 3, 4 and 7. Area covered by system is 270 sq.km with cell radius 2 km. Calculate system capacity for cluster size 3, 4 and 7.

Answer the following questions

1. What is FDD.
2. Define cluster and draw cluster of size N=3&7, Repeat it 3 times.
3. Explain frequency reuse concept.

Result analysis and conclusion

Sr No	N	M	Sys Cap
1	3	9	6003
2	4	7	4669
3	7	4	2668

The number of cluster increases then the system capacity decreases from 6003 to 2668

Calculations :-

Given Parameters :-

N = 3, 4, 7

Area = 270 Sq. Km

r = 2 Km

frequency band = 40 MHz (duplex)

user bandwidth = 30 KHz (simplex)

i) no of channel = $\frac{40 \times 10^3}{60} = 667$ (s)

ii) cell area = $\frac{3\sqrt{3}}{2} \cdot r^2 = \frac{3\sqrt{3}}{2} \times (2)^2 = 10.39$ Sq Km

iii) total no of cell = $\frac{270}{10.39} = 25.98 \cong 26$

N = 3

$M = \frac{26}{N} = \frac{26}{3} = 9$

System Capacity = M x S

= 9 x 667

= 6003

N = 4

$M = \frac{26}{N} = 6.5 \cong 7$

System Capacity = M x S

= 7 x 667

= 4669

N = 7

$M = \frac{26}{7} = 3.7 \cong 4$

System capacity = 4 × 667

= 2668

1) What is FDD?

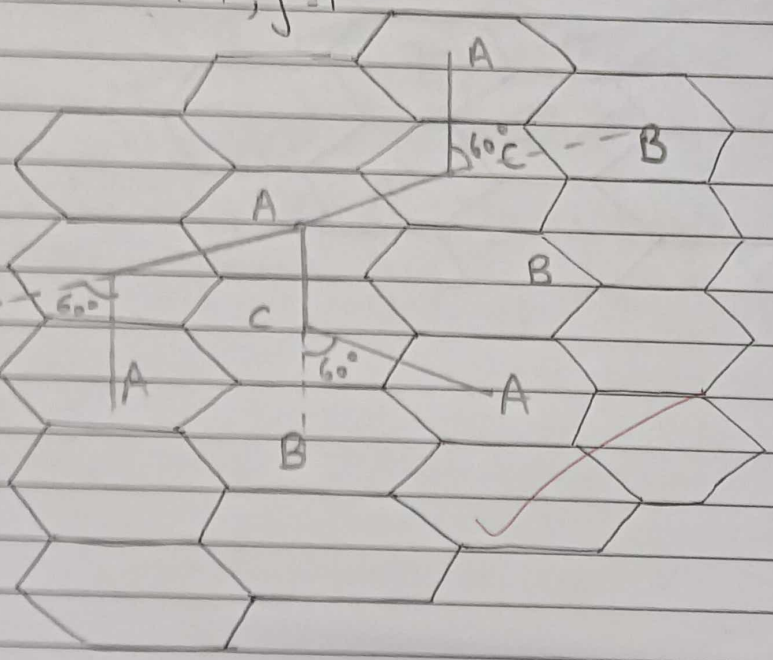
→ Frequency Division Duplexing (FDD) allows transmission of radio channels simultaneously for the base station and the subscriber so that both can continuously transmit and at the same time receive signals.

2) Define cluster and draw cluster of size N = 3 & 7, Repeat it 3 times

→ Cluster is a group of cells which are collectively uses all the available channel.

It is defined by N (no of cells)

N = 3 i = 1, j = 1



$N = i^2 + j^2 + ij$

$= 1^2 + 1^2 + 1 \times 1$

$= 1 + 1 + 1$

$N = 3$

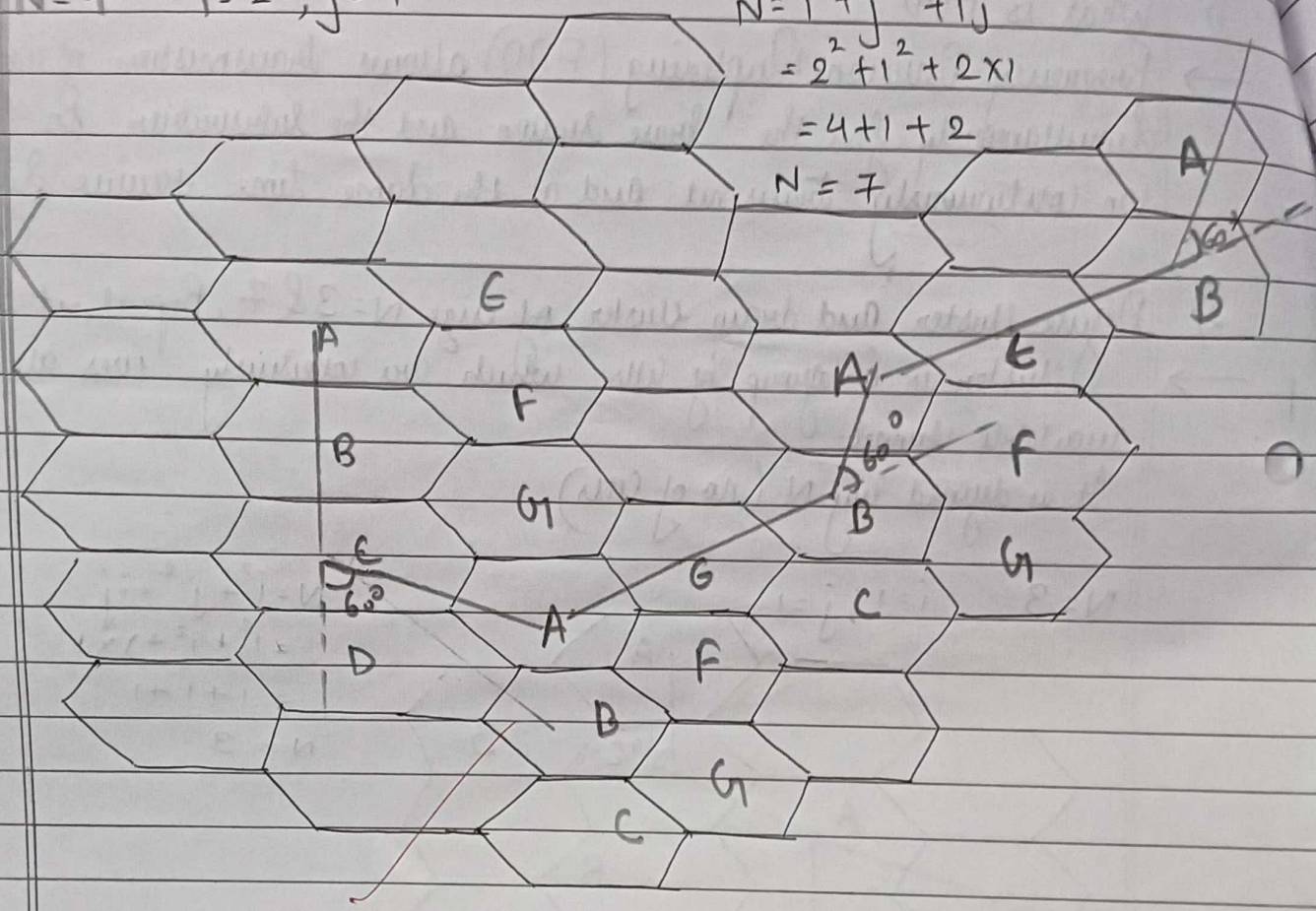
N = 7 i = 2 , j = 1

$N = i^2 + j^2 + ij$

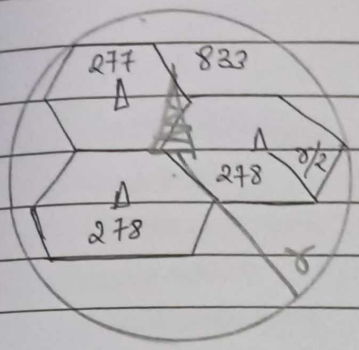
$= 2^2 + 1^2 + 2 \times 1$

$= 4 + 1 + 2$

$N = 7$



3) Explain frequency reuse concept.



Maximum no of users are 833.

To increase the system capacity (more no of users), same set of channels (frequency) are request called frequency reuse.
Example FM Radio.

- cells using the same set of frequency are co-channels cells.
- To implement frequency reuse concept formation is needed.

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Experiment No. - 3

AIM **To analyze the effect of propagation path loss exponent on cluster size and Signal to Interference Ratio.**

Theory Cluster is defined as the group of cells which collectively uses the complete set of available channels. The cluster size N is defined as $N = i^2 + j^2 + ij$.
where i and j are non-negative integers. The signal to interference ratio **(SIR)** for a forward link is defined as

$$\frac{S}{I} = \frac{S}{\sum_{i=1}^{6} Ii}$$

where **S** is the signal power received by the user transmitted by its BS and **Ii** is the interference power received by the user from all the co- channel cells (Reuse)

$$SIR = \frac{R^{-n}}{\sum_{i=1}^{6} Di^{-n}}$$

where **R** is the distance between user and its BS and **Di** is the distance between user and all co channel cell BS. Assume all the co channel cells are at equidistance ($D_1 = D_2 = D_3 = D_4 = D_5 = D_6$)

$$\frac{S}{I} = \frac{R^{-n}}{\sum_{i=1}^{6} Di^{-n}} = \frac{(D/R)^n}{6}$$

$$\frac{S}{I} = \frac{(D/R)^n}{6} = \frac{(\sqrt{3N})^n}{6}$$

Where **n** is the propagation path loss exponent

Problem In a mobile system minimum S/I ratio of 15db is required to maintain a call what should be cluster size when path loss exponent is 3 and 4. If there are 6 co channel cells and analyze the results.

Answer the following question

1. What is the relation between frequency reuse ratio and system capacity?
2. Explain co-channel and adjacent channel interference.
3. Explain channel assignment schemes.

Result Analysis and Conclusion In this experiment, we have calculated cluster size (N) for different path loss experiment (n) in MATLAB and also check whether the cluster size is a valid cluster or not if it is not a valid cluster size then we have assigned the nearest valid cluster size.

Post Experiment Questions

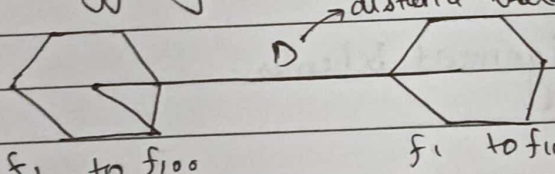
Q1. What is the relation between frequency reuse ratio and system capacity?

→ The frequency reuse ratio is inversely related to the system capacity. A lower frequency reuse ratio increases the number of cells that can reuse the same frequency; thereby enhancing the system capacity by allowing more simultaneous users within a given area.

Q2. Explain co-channel and adjacent channel interference

→ • Co-channel Interference:-

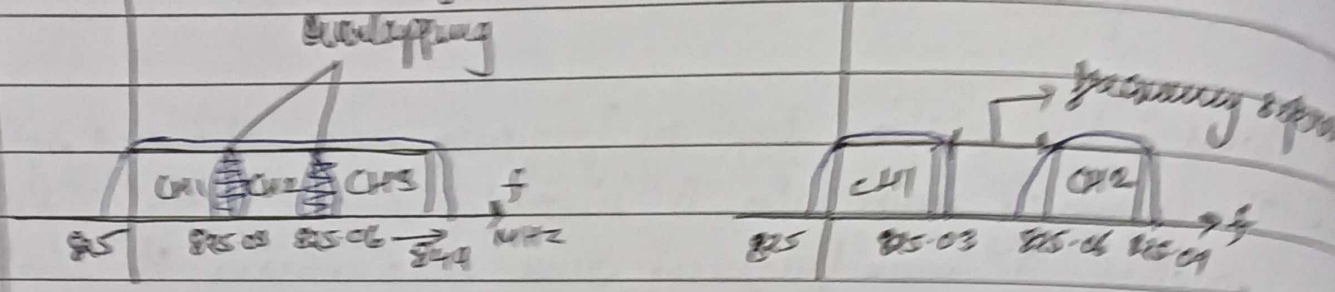
- It occurs when two cells using the same frequency interfere with each other, affecting the quality of communication.



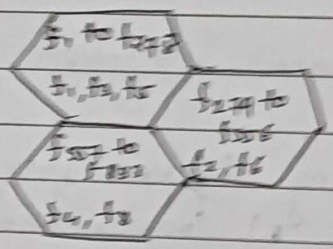
- To reduce co-channel interference increase the distance between cells using the same frequency.

• Adjacent channel Interference:-

- It happens when frequencies that are close to each other in the spectrum cause overlapping leading to interference and degraded signal quality.
- To reduce adjacent channel interference implement guard bands, which are small frequency gaps between adjacent channels to prevent overlap.
- Carefully plan and assign channels to ensure that adjacent channel are not used in close proximity.

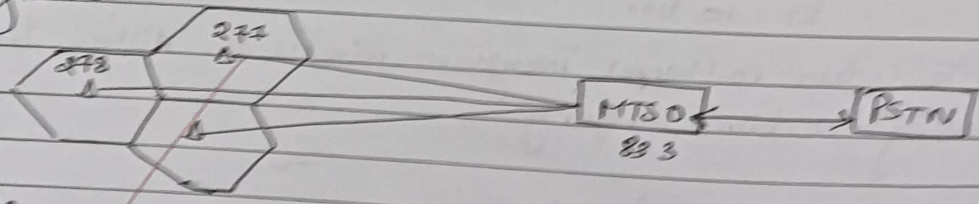


Example N = 3



Q3- Explain channel assignment schemes.

→ 1) Fixed / Static
2) Dynamic



1) Static

- In static channel assignment fixed set of frequency assigned to each cell if the cell request is more than the no of assigned channel all the additional/excess call request will be blocked by the system.
- To solve this cell can borrow the channel, borrowed channel should not be adjacent to the assigned set of channels.

2) Dynamic

In Dynamic Channel assignment, channels are assigned to cells on demand, based on the current traffic load. i.e there is no allocation of predetermined set of channels. This strategy is more efficient than FCA, but it is also more complex to implement.

Erlang and $\lambda = 1$ call/hour, compute the following for an Erlang C system that has a probability of 5% of a delayed call.

1. How many users per sqkm. will this system support.
2. What is the probability that a delayed call will have to wait for more than 20 sec?
3. What is the probability that a call will be delayed for more than 20 sec.?
4. What is the probability that a delayed call will have to wait for more than 10 sec?
5. What is the probability that a call will be delayed for more than 10 sec.?
6. What is the probability that a delayed call will have to wait for more than 5 sec?
7. What is the probability that a call will be delayed for more than 5 sec.?

Answer the following question

Define the following terms-

1. Holding time
2. Traffic Intensity
3. Grade of service
4. Call drop and call blocked.

Result Analysis and Conclusion:

Sr No	Delay	Pr (delay > t)	Blocking Pr
1	5 sec	0.71	3.5 %
2	10 sec	0.51	2.5 %
3	20 sec	0.26	1 %

As delay time increase blocking Probability decrease.

Problem :-

Given Parameters :-

$N = 4$

$r = 1.56$ km

no of channel = 80 channels

$A_u = 0.029$ Erlang

$\lambda = 1$ call/hr

$P_r(\text{delay} > t) = 5\%$

i) no of channel / cell $(C) = \frac{80^{20}}{4_1} = 20$

Erlang C table $C = 20$ & $P_r = 5\%$.

load or traffic intensity $(A) = 13$ erlang (from table)

No of user / sq km.

Cell area $= \frac{3 \times \sqrt{3}}{2} \cdot R^2$

$= \frac{3 \times \sqrt{3}}{2} \times (1.56)^2$

$= 6.32$ sq km

no of user in a cell

$A = U A_u$

$U = \frac{13}{0.029}$

$= 448.2$ users.

6.328 sq.km — 448.2 users

1 sq.km — 70.91 users.

$AU = \lambda H$

$H = \frac{A_y}{\lambda}$ (always sec)

$= \frac{0.029}{1}$

$= 0.029 \times 60 \times 60$

$= 104.4$

ii) $P_r(\text{delay} > t) = e^{-(c-A)t/h}$

$= e^{-(20-13)\,5/104.4}$

$= 0.71$ sec

$P_r(\text{delay} > t) = e^{-(c-A)t/h}$

$= e^{-(20-13)\,10/104.4}$

$= 0.51$ sec

$P_r(\text{delay} > t) = e^{-(c-A)t/h}$

$= e^{-(20-13)\,20/104.4}$

$= 0.26$.

$P_r(\text{delay} > t) = P_r(\text{delay} > 0) \times P_r(\text{delay} > t) / P_r(\text{delay} > 0)$

$= 0.05 \times 0.26$ $(t = 20s)$

$= 0.013$

$= 1\%$

$= 0.05 \times 0.51$ $(t = 10s)$

$= 0.025$

$= 2.5\%$.

$= 0.05 \times 0.715$ $(t = 5s)$.

$= 0.035$

$= 3.5\%$.

Post Experiment :-

* Define the following terms :-

1) Holding time :- Average duration of calls and it is always measured in seconds.

2) Traffic intensity :- Measure of channel time utilization, the average number of calls simultaneously in progress during a particular period of time (busy hour). It is measured in Erlang.

- Traffic Intensity is defined by two Parameters :-
i) Call rate or call request rate (λ) - Average number of call request per unit time (calls / hour)
ii) Call Holding time (H) - Average duration of a call. It is defined in seconds.

3) Grade of service :- It is a measure of the ability of a user to access a trunked radio system during the busiest hour.

4) Call drop and Call blocked :-
Call drop - A call drop occurs when an active call is abruptly terminated due to issues like weak signal strength, handover failure between cells or network disruptions. This happens when the mobile network fails to maintain the connection during an ongoing call.
Called blocked :- A blocked call refers to a call attempt cannot be completed at the time of request due to network congestion or the unavailability of a channel.

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For large city:

$$\alpha_r(dB) = 8.29(log1.54h_r)^2 - 1.1 \qquad for\ f_c \leq 300MHz$$
$$\alpha_r(dB) = 3.2(log11.75h_r)^2 - 4.97 \qquad for\ f_c > 300MHz$$

For small city:

$$\alpha_r(dB) = (1.1logf_c - 0.7)h_r - (1.56logf_c - 0.8)$$

The median path loss in Suburban area

$$L_{pH}(dB) = L_{pH}(Urban)(dB) - 2\left[log\left(\frac{f_c}{28}\right)\right]^2 - 5.4$$

The median path loss in Open Rural area

$$L_{pH}(dB) = L_{pH}(Urban)(dB) - 4.78(logf_c)^2 + 18.33logf_c - 40.94$$

Hata model is not suitable for Personal Communication Systems.

Problem: Determine the propagation path loss of a 700MHz and 900MHz cellular system operating in a large city from a BS with antenna height of 100m and mobile unit installed in a vehicle with an antenna height of 4m, when the mobile user is travelling distance of 2km to 25km from the BS.

Answer the following questions:

1. Why is propagation path-loss is one of the key parameters used in the analysis of radio wave propagation for mobile communication.
2. Explain Rayleigh and Rician fading.

Result analysis and Conclusion: As the distance increases, the propagation path loss increases. Higher the frequency higher the propagation path loss

DATE:

Q1. Why is Propagation Path-loss is one of the key parameter used in the analysis of radio wave Propagation for mobile communication

→ Propagation Path-loss is a vital parameter in the analysis of mobile communication for several reasons:-

1) Reduction in Signal Strength - Path loss measures how much the strength of a signal decreases as radio waves travel through space, primarily due to distance and environmental factors.

2) Link budget calculations :- It plays a crucial role in link budget analysis, helping engineers ensure that signals remain strong enough for reliable communication over various distances.

3) network planning - Accurate modeling of Path loss assists in optimally placing base stations and antennas, there by enhancing coverage and minimising dead zones.

4) Performance optimisation - understanding Pathloss allows for adaptive management of power levels and modulation techniques to maintain service quality under different conditions.

Q2. Explain Rayleigh and Rician fading

→ 1) Rayleigh fading

- If there are large number of multiple reflective paths and no line of sight path (NLOS) it is Rayleigh fading.
- Rayleigh distribution is used to describe statistical time varying nature of the received fast fading signal.
- The Rayleigh distribution has a probability density function
- $p(r) = \frac{r}{\sigma^2} \exp\left(\frac{-r^2}{2\sigma^2}\right)$ $0 \le r \le \infty$
  $= 0$ $r < 0$

DATE:

• σ is scalar parameter of the distribution

2) Rician fading:

• Rician fading means non fading signal component is present in line of sight (LOS) propagation path.

• The Rician distribution is given as

$$p(r) = \frac{r}{\sigma^2} \exp\left(\frac{-r^2 + A^2}{2\sigma^2}\right) I_0\left(\frac{Ar}{\sigma^2}\right) \quad \text{for } A \geq 0, r \geq 0$$

$$= 0 \quad \text{for } r < 0$$

where A is the peak amplitude of the dominant signal.

• $K = \frac{A^2}{2\sigma^2}$, K is defined as the ratio between the deterministic signal power and the variance of the multipath.

• K is also called Rician factor.

• As $A \to 0$, $K \to \infty$ the Rician distribution degenerates to Rayleigh distribution.

DATE:

Problem :-

Given Parameter :-

$f_c = 700, 900 MHz$

$h_t = 100m$

$h_r = 4m$

$r = 2 \text{ to } 25 km$

$L_{ph} = 68.75 + 26.16 \log f_c(MHz) - 13.82 \log h_t - \alpha_r + (44.9 - 6.55 \log h_t) \times \log r$

$\alpha_r = 3.2 \log (11.75 \times h_r)^2 - 4.97$

$\alpha_r = 3.2 \log (11.75 \times 4)^2 - 4.97$

$\alpha_r = 3.97$

$L_{ph} = 68.75 + 26.16 \log(700) - 13.82 \log(100) - 3.97 + (44.9 - 6.55 \log(100)) \times \log(2)$

$= 121.14$

$\alpha_{r_2} = 3.2 \log (11.75 \times h_r)^2 - 4.97$

$\alpha_{r_2} = 3.97$

$L_{ph_2} = 68.75 + 26.16 \log(900) - 13.82 \log(100) - 3.97 + (44.9 - 6.55 \log 100) \times \log(2)$

$= 123.99$

$$fd = \frac{1}{\lambda c} v_m \cos\theta$$

Received carrier frequency $= f_c + f_d$

3. If the mobile user is moving away from the BS with an angle θ w the transmitted signal

$$fd = \frac{1}{\lambda c} v_m \cos\theta$$

Received carrier frequency $= f_c - f_d$

Problem:

In GSM mobile radio BS operating at 900 MHz. A mobile user is moving at a speed of 70 km/hr. Calculate the received carrier frequency if:

1. Mobile user moving directly away from BS.
2. Mobile user moving towards BS.
3. Mobile user moves 30° & 60° to the direction of arrival of transmitted signal.
4. Mobile user moves 30° & 60° away from the transmitted signal.

Answer the following Questions

1. What is multipath fading.
2. Explain small-scale & large-scale fading.
3. Explain coherence bandwidth

Result analysis and Conclusion:

Sr. No	θ	fd	fd (new)
1.	180°	-58.72	900MHz - 58.7Hz
2.	0°	58.72	900MHz + 58.7Hz
3.	30°	51.02	900MHz + 50.9Hz
4.	60°	29.46	900MHz + 29.3Hz
5.	150°	-51.02	900MHz - 51.02Hz
6.	120°	-29.46	900MHz - 29.46Hz

As the user moves towards or away from the base station, change in frequency is maximum.

Q1. What is multipath fading

→ Multipath fading is a phenomenon in wireless communication where a signal reaches the receiver via multiple paths due to reflection, diffraction and scattering caused by obstacles like buildings, mountains or atmospheric layers. These multipath signals can cause fluctuation in the signal strength.

- Multipath Propagation increases the time required for broadband signals to reach the receiver (time delay of signal arrival)

Q2. Explain Small-Scale and large scale fading

→ i) Small Scale fading or fast fading - Rapid fluctuations of received signal strength over short time intervals and/or travel distances.

This fading is caused by multipath propagation, where multiple copies of the signal arrive at the receiver from different paths due to reflection, diffraction or scattering.

ii) Large scale fading or slow fading - Slowly varying properties of the signals that depends primarily on the distance between Tx and Rx. This type of fading is caused by obstacles like buildings, terrain or large objects that block.

Q3. Explain coherence bandwidth

→ ⑥ The coherence Bandwidth characterize the channel in frequency domain

- It is defined as the Bandwidth over which channel has constant gain and linear phase.
- Also called Bandwidth over which channel is flat.
- It is also defined as range of frequency over which two frequency components have strong potential for amplitude correlation.
- If the correlation is above 0.9 the B_c is

$$B_c = \frac{1}{50\sigma_\tau}$$

- If the correlation is above 0.5 the B_c is

$$B_c = \frac{1}{5\sigma_\tau}$$

- σ_τ is the average rms delay spread.

Divide the answer obtained by total no. of bits in PN sequence	4/4= 1	-4/4= -1	4/4= 1
Converting to binary, we get	1	0	1

User 2 data decoding:

Received	2 -2 0 0	0 0 -2 2	0 0 2 -2
Multiply with PN sequence 2	1 -1 -1 1	1 -1 -1 1	1 -1 -1 1
=	2 2 0 0	0 0 2 2	0 0 -2 -2
Add the bits	2+2+0+0= 4	-2-2+0+0= 4	0+0-2-2= -4
Divide the answer obtained by total no. of bits in PN sequence	4/4= 1	4/4= 1	-4/4= -1
Converting to binary, we get	1	1	0

Problem:

user 1= 101
user 2= 111
PN sequence 1= 1001
PN sequence 2= 1010

Answer the following questions:

1. Compare FDMA, TDMA and SSMA.
2. Advantages of CDMA over TDMA & FDMA

Result Analysis and Conclusion: The implementation of the CDMA system with two users transmitting data over a single carrier demonstrates the effectiveness of using orthogonal codes to separate user signals. The results show that the system successfully minimizes interference between users leading to accurate data recovery with low bit error rates.

Q. Compare FDMA, TDMA and SDMA

Paramater	FDMA	TDMA	SDMA
1. Method	Overall bandwidth is shared among many stations.	Time sharing of satellite transponder take place.	Available space is divided into cells or sectors
2. Interference effect	Due to nonlinearity of transponder amplifier inter modulation products are generated due to interference between adjacent channel.	Due to incorrect synchronization there can be interference between the adjacent time slot.	Both type of interference will be present.
3. Synchronization	Synchronization is not necessary.	Synchronization is essential.	Synchronization is not necessary.
4. Code used	Code word is not required.	Code word is not required.	Code word is not not required.
5. Guard times and bands.	Guard bands between adjacent channels are necessary	Guard times between adjacent time slot are necessary	Guard bands and guard times both are necessary.

6. Handover	Hard Handover	Soft handover	Soft Handover
7. Frequency reuse	7	7	1
8. Required Channel bandwidth	0.03 MHz	0.03 MHz	1.25 MHz
9. System complexity	lower	Higher	Higher
10. System flexibility	Simple and Robust inflexible.	flexible	flexible.

Q2. Advantages of CDMA over time TDMA and FDMA.

1. Higher capacity & Efficiency - CDMA allows multiple users to share the same frequency spectrum simultaneously by using unique codes. This leads to higher system capacity and better spectrum efficiency compared to TDMA and FDMA, where the number of users is limited by time slots and frequency channels.
2. Efficient use of power - CDMA allows for variable transmission power based on signal quality, leading to more efficient power use and longer battery life for mobile devices compared to TDMA and FDMA, where power levels are more static.

Problem :-

user 1 = 101

user 2 = 111

PN sequence 1 = 1001

PN sequence 2 = 1010

user 1 : 1 0 1

1 -1 1 Polar form

PN1 : 1001 1001 1001

1-1-11 1-11-1 1-1-11 Polar form

| 1-1-11 | 1-11-1 | 1-1-11 | - user-1 (spreaded data)

user 2 : 1 1 1

1 1 1 Polar form

PN2 : 1010 1010 1010

1-11-1 1-11-1 1-11-1 polar form

| 1-11-1 | 1-11-1 | 1-11-1 | user 2 (spreaded data)

Addition of user 1 & user 2 : 2 -200 002-2 2-200

Rx at the receiver demodulates the signal

2 -200 00 2-2 2-2 00 } x

PN 1 = 1 -1 -1 1 1 -1 -1 1 1 -1 -1 1

= 2 2 00 00 -2 -2 2 2 0 0

Add the bits = 2+2+0+0 = 4 | 0+0-2-2 = -4 | 2+2+0+0=4

divide the answer obtained by total no of bits in PN sequence

$\frac{4}{4} = 1$ $\frac{-4}{4} = 1$ $\frac{4}{4} = 1$

Convert to binary 1 0 1

User 2 data decoding

PN 2 = 1 -1 1 -1 = 2 2 0 0

2 -2 0 0 0 0 2 -2 2 -2 0 0 ×
1 -1 1 -1 1 -1 1 -1

0 0 2 2 2 2 0 0

Add the bits $-2+2+0+0=4$ $0+0+2+2=4$ $2+2+0+0=4$

Divide the answer obtained by total no of bits in PN sequence.

$\frac{4}{4} = 1$ $\frac{4}{4} = 1$ $\frac{4}{4} = 1$

Convert to binary 1 1 1

Example: $W_1 = 1\ 0\ 1\ 0$

$W_2 = 0\ 1\ 1\ 0$

No. of bits agreement =2

No. Of bits disagreement =2

$\therefore \frac{2-2}{4} = 0$

(b) Orthogonal functions have zero cross correlation. It is obtained if the product of the two signals summed over a period of time is zero. Thus, when the XORing of two binary sequences results in an equal number of 1 and 0 the cross correlation is zero.

$W_1 = 1\ 0\ 1\ 0$

$W_2 = 0\ 1\ 1\ 0$

$0\ 0\ 1\ 1$

No. of 1 s = 2

No. of 0 s = 2

Hence W1 and W2 are orthogonal

Answer the following question

1. Functions of Walsh code in IS-95 CDMA system in forward link and reverse link.
2. Applications of Walsh codes.

CONCLUSION: Walsh codes can be generated using a Hadamard matrix, where the orthogonality between the rows is verified by calculating the dot product & dot product of zero. This orthogonality is essential for minimizing interference in CDMA systems, making walsh codes highly effective for separating logical channels.

Q1: Functions of Walsh code in IS-95 CDMA Systems in forward link and reverse link

→ 1) On the forward link, Walsh codes are used for orthogonal spreading to separate different logical channels and avoid interference between users and channels.
· They are applied to various logical channels.
i) Pilot channel (W_0)
· It provides reference signal for coherent demodulation and helps in HO Process
· Pilot signal always transmitted 4dB - 6dB higher power as compared to any other control channel.
ii) Synchronization channel (W_{32})
· It provide time and frame synchronization. It used to carry the information such as System ID, Network ID and At what rate paging channel will transmit the information
· The pilot channel control signal spreaded by W_{32}.
iii) Paging channels (W_1 to W_7) PACH.
· Acknowledgement of call function
· It used to transmit the link messages from system.
iv) Traffic channel (TCH) (W_8 to W_{31}, W_{33} to W_{63})
· Carry user-specific voice of data transmission

2) Reverse link - On the Reverse link, Walsh code are used for modulation to encode data within a single user's transmission.
· The logical channel are
i) Access channel.
· Helps in call origination and initiation

. Acknowledge the call request from the third party.
. It always transmitted at 4.8 K bps.

2) Traffic channel
. Carries user data from the mobile station to the base station.

Q2) Applications of Walsh codes.

i) CDMA Systems :- used for spreading data signals and enabling multiple users to share the same frequency without interference

ii) Channelization :- creates distinct logical channels for pilot, synchronization, paging and traffic in systems like IS-95.

iii) Fast Walsh - Hadamard Transform (FWHT) :-
Walsh functions are used in FWHT for various application including filtering, power spectrum analysis, and coding. The FWHT allows efficient computation of the walsh transform which is useful in signal processing task.

iv) Error - correcting codes :- derived from Hadamard matrices, walsh codes can be used to design powerful Error - correcting codes that enhances data transmission reliability over long distances, such as those used in space communications.

v) Multiplexing of channels :- Walsh codes are used to multiplex multiple channels over the same transmission medium.

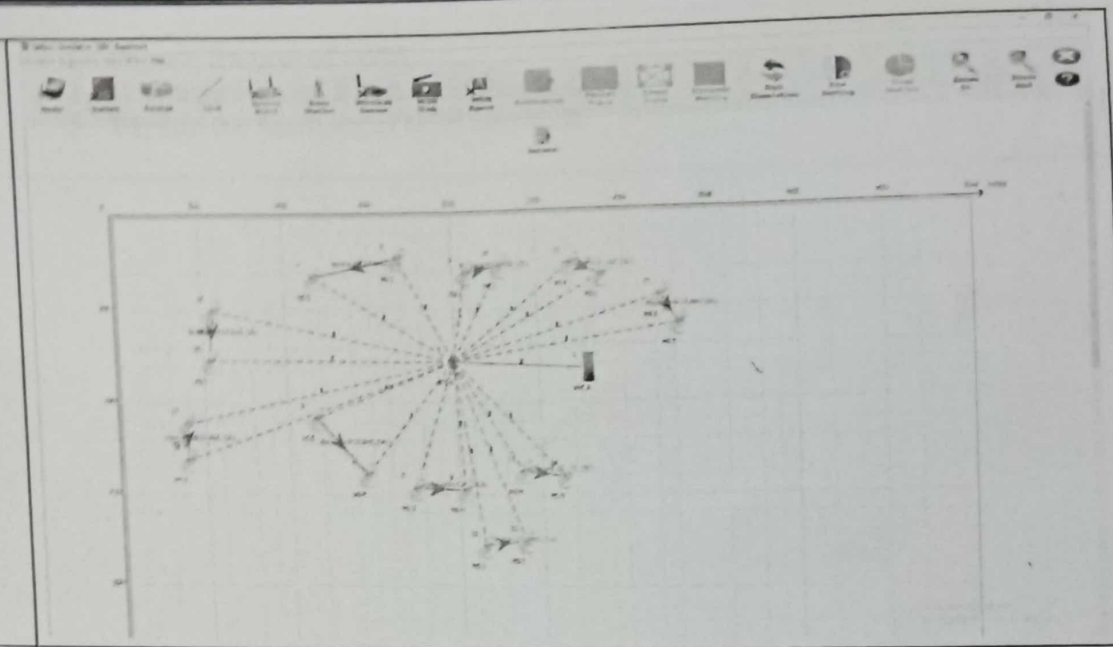


Figure – 1 (GSM network scenario with 20 MS)

- After simulation, go to the cellular metrics.
- In channel metrics, the channel count is mentioned.
- In MS metrics, the call generated, and call blocked is shown for each MS. Add the call blocked for all MS Ids.

Call Blocking Probability= $\frac{\text{Total calls blocked}}{\text{Total calls generated}}$

Observations:

S.No.	Number of MS	Call Blocking Probability
1	4	
2	6	0/2 = 0
3	8	9/12 = 0.75
4	10	10/13 = 0.769
5	12	45/46 = 0.978
6	14	51/54 = 0.944
7	16	
8	18	
9	20	

Result analysis and Conclusion:

Call blocking depends on traffic intensity as observed in above table as the number of mobile station increases probability of call blocking also increases.

Q1. Explain features of GSM

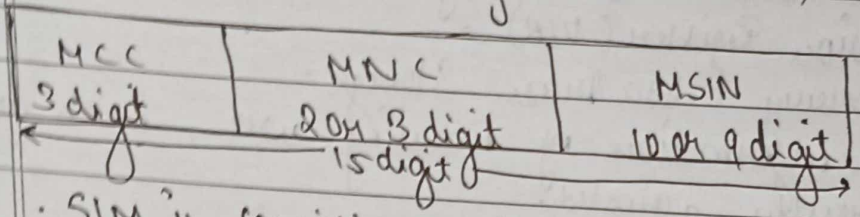
→ i) SIM (Subscriber identity Module) :-

- SIM gives the identity to the mobile subscriber / hand.
- It is programmed with 15 digit International mobile Subscriber identity (IMSI)

MCC - 3 digit

MNC - 2 or 3 digit

Mobile subscriber identity number (MSIN) : 10 or 9 digits.



- SIM is consisting of home location of username of the network and countries where user can access the system also the types of services for which the user is authorized.

ii) On air Privacy :- (Voice & data Security)

- On air Privacy is provided by encryption algorithm & encryption keys.
- This 64 bit encryption key is stored in the SIM.

Q2. Why transmission is discontinuous in GSM.

→ Speech Coder (Voice Coder) is always provided with voice Activity detector it will detect the Active Period of time and turns on the transmitter during inactive period it will turnoff the transmitter and increases the battery life.

Q3. Explain the functions of HLR and VLR.

→ i) Home location Register (HLR):-

- It is centralized database register, which stores the user profile permanently:
- User's IMSI number
- Services subscription information
- Billing/accounting information
- Determine the current location of the user.

ii) Visitor location Register (VLR):-

- It is a temporary database storage.
- It stores the information of roaming user, such as
- features currently activated.
- Temporary mobile station identity (TMSI)
- Current location information of roaming user.

Answer the following question

1) What is diversity and explain types of diversity.
2) How RAKE receiver improves the gain.

Conclusion: The effectiveness of multipath diversity in improving the performance of CDMA systems. By using a RAKE receiver, which combines multiple signal paths, the system enhances the signal-to-noise ratio (SNR) and significantly reduces bit error rate (BER). Increasing the number of RAKE receiver taps and the spreading factor further lowers the BER, improving reliability. Overall, exploiting multipath diversity through RAKE receivers boosts the robustness and efficiency of wireless communication in CDMA systems.

Sr. No	Spreading factor	No. of taps	BER at SNR = 5dB
1.	256	L = 3	3.83×10^{-6}
		L = 4	1.33×10^{-5}
2.	128	L = 3	1.54×10^{-5}
		L = 4	5.34×10^{-5}

Post Experiment

Q1. What is diversity and explain types of diversity.

→ Diversity is a technique used in wireless communication to mitigate the effects of fading by providing multiple independent versions of the transmitted signal. The types of diversity include :-
Time diversity :- Sending signals at different times.
Frequency diversity :- Using multiple frequency bands.
Space diversity :- Using multiple antennas.
Polarization diversity :- Using different polarization schemes.
Multipath diversity :- Leveraging multiple signal paths.

Q2. How does the RAKE receiver improve gain?

→ A RAKE receiver improves gain by combining multiple versions of the signal received via different multipath components. It uses correlators, or "fingers" to align and combine these signals, maximizing the Signal-to-Noise Ratio (SNR) and reducing Bit Error Rate (BER). This improves the systems performance by exploiting multipath diversity.