EXPERIMENT NO: 1

NAME OF THE EXPERIMENT: Capacity of Cellular system

I) AIM: To observe the effect of N on Capacity and C/I ratio and comment on the voice quality

II) APPARATUS :

1. PC
2. Printer
3. Matlab

III) THEORY:

The design objective of early mobile radio systems was to achieve a large coverage area using a single, high powered transmitter with an antenna mounted on a tall tower The cellular concept is a system-level idea which calls for replacing a single, high power transmitter (large cell) with many low power transmitter (small cells) each providing a coverage to only a small portion of the service area While it might seem natural to choose a circle to represent the coverage of a BS, adjacent circles cannot be overlaid upon a map without leaving gaps or creating overlapping regions Thus when considering geometric shapes which cover an entire region without overlap and with equal area, there are three sensible choices a square, an equilateral triangle and a hexagon The actual radio coverage of a cell is known as footprint and is from field measurements or propagation prediction models

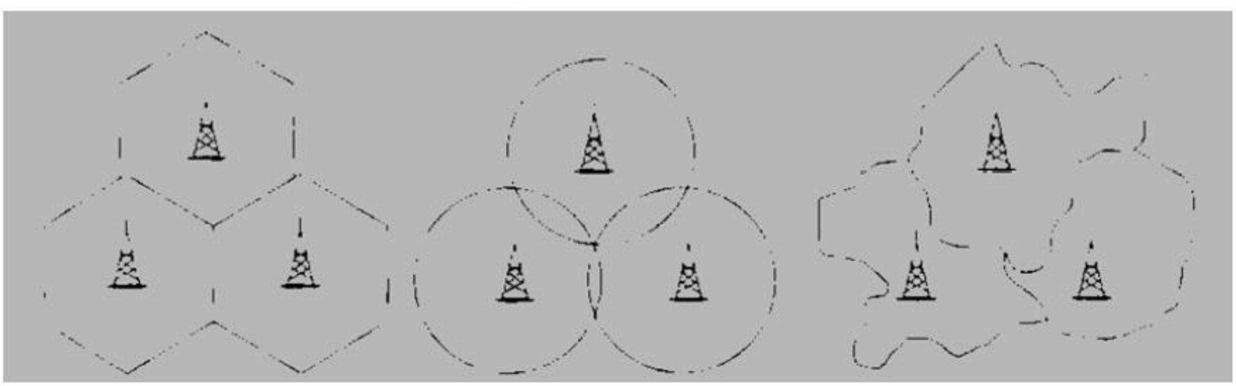


Fig. 1 (a) Theoretical Coverage (b) Ideal Coverage (c) Real Coverage

Why hexagon for theoretical coverage?

For a given distance between the center of a polygon and its farthest perimeter points, the hexagon has the largest area of the three Thus by using hexagon geometry, the fewest number of cells can cover a geographic region, and hexagon closely approximates a circular radiation pattern which would occur for an omnidirectionl BS antenna and free space propagation When using hexagons to model a coverage areas, BS transmitters are depicted as either being in the center of the cell (center-excited cells) or on the three of the six cell vertices (edge-excited cells) Normally omnidirectional antennas are used in center-excited cells and directional antennas are used in corner-excited cells

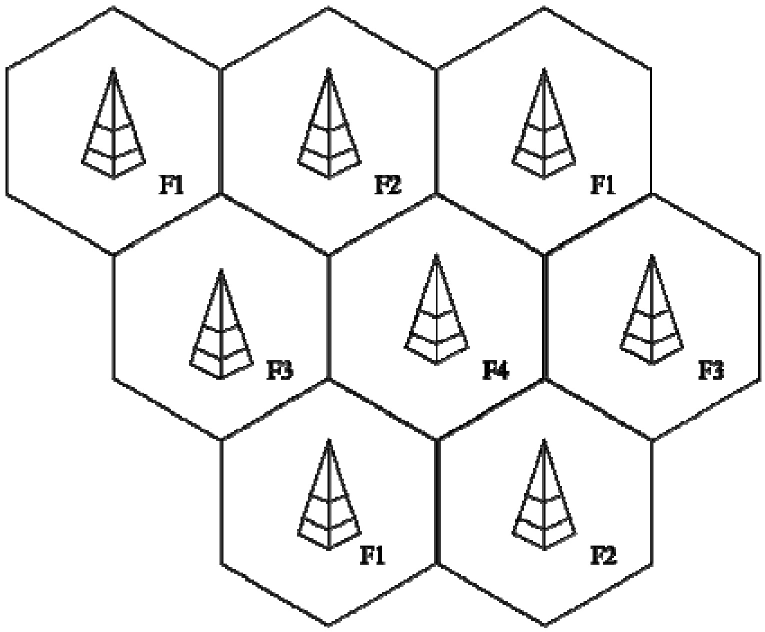


Fig. .2 Center-excited cells with Omni directional antennas

Why cellular systems*?*

Solves the problem of spectral congestion

Reuse of radio channel in different cells

Enable a fixed number of channels to serve an arbitrarily large number of users by reusing the channel throughout the coverage region

Frequency reuse:

Each cellular BS is allocated a group of radio channels to be used within a small geographic area called *cell* BS in adjacent cells are assigned channel groups which contain completely different channels than neighboring cell.By limiting the coverage area to within the boundaries of a cell, the same groups of channels may be used to cover different cells that are separated from one another by distances large enough to keep the interference levels within tolerable limits .The design process of selecting and allocating channel groups for all of the cellular BSs is called *frequency reuse or frequency planning*

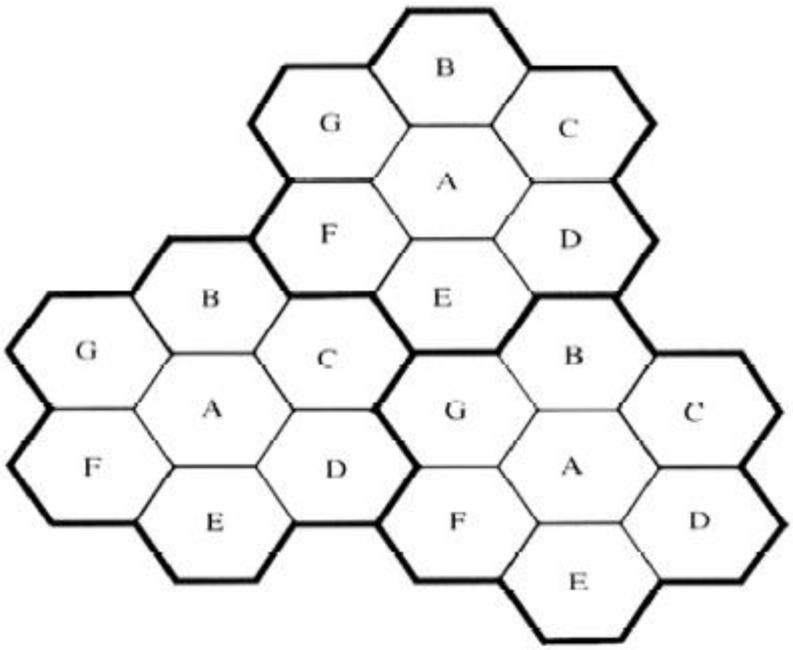
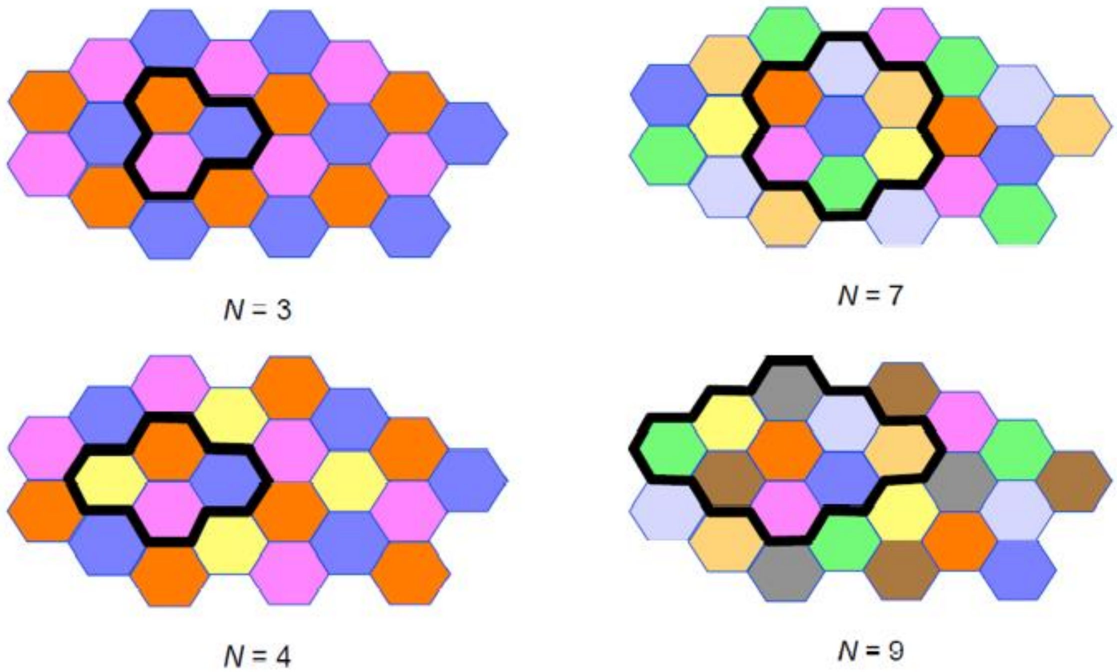


Fig. 3 Illustration of the cellular frequency reuse concept.

Cluster and Capacity:

Consider a cellular system which has a total of S duplex channels available for use . If each cell is allocated a group of k channels (k<S), and if the S channels are divided among N cells and disjoint channel groups which each have same number of channels, the total number of available radio channels can be expressed as S=kN

N cells which collectively use the complete set of available frequencies is called a *cluster*



If a cluster is replicated M times within the system, the total number of duplex channels, C, can be used a measure of capacity and is given by
C=MkN=MS
So the capacity of a cellular system is directly proportional to the number of times a cluster is replicated in a fixed service area A larger cluster size causes the ratio between the cell radius and the distance between the co-channel cells to decrease, leading to weaker co-channel interference Conversely a small cluster size indicates the co-channel cells are located much closer together .From a designer point of view, t he smallest possible value of N is desirable in order to maximize capacity over a given coverage area
In order to tessellate connect without gaps between adjacent cells the geometry of the hexagon is such that number of cells per cluster N can have

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

where i and j are non-negative integers

IV) PROCEDURE:

1. Write a matlab program to calculate capacity of cellular system
2 for that input are i,j to calculate cluster size N.
3. user defined area and radius of cell R
4. total 40 Mhz Bandwidth allocated to particular cellular telephone system which uses 60Khz duplex channel.

5. Calculate capacity of system: by varying N,R and S/I
6.Make a table for various inputs
7.Take printout of output and program

i	**j**	**N**	**M**	**K**	**C**	**S/I db**
1	1					
0	2					
1	2					
0	3					

V) PROGRAM:

VI) CONCLUSION :

The capacity of a cellular system is directly proportional to the number of times a cluster is replicated in a fixed service area
Tradeoff between capacity and co channel interference

VII) SAMPLE EXPERT VIVA VOCE QUESTION

1. What is frequency reuse
2. Explain capacity of cellular system
3. What is relation of cluster size and capacity
4. What is impact on co channel interference of varying cluster size

EXPERIMENT NO: 2

NAME OF THE EXPERIMENT: Effect of C/I ratio in a sectored cell site

I) AIM: To observe the effect of C/I ratio in a sectorised cell site and perform worst case analysis for different values of N and degree of sectorisation

A) Worst case C/I in a 3 sector cellular system for N=7
B) Worst case C/I in a 3-sector cellular system for N=4
C) Worst case C/I in a 6 sector cellular system for N=7
D) Worst case C/I in a 6 sector cellular system for N=4

II) APPARATUS :

1. PC
2. Printer
3. MATLAB software

III) THEORY:

Sectoring is basically a technique which can increase the SIR without necessitating an increase in the cluster size. Till now, it has been assumed that the base station is located in the center of a cell and radiates uniformly in all the directions behaving as an omnidirectional antenna. However it has been found that the co-channel interference in a cellular system may be decreased by replacing a single omni-directional antenna at the base station by several directional antennas, each radiating within a specified sector(Fig.1). The base station feeds three 120o directional antennas, each of which radiates into one of the three sectors. The channel set serving this cell has also been divided, so that each sector is assigned onethird of the available number cell of channels. This technique for reducing co-channel interference wherein by using suitable directional antennas, a given cell would receive interference and transmit with a fraction of available co-channel cells is called 'sectoring'. In a seven-cell-cluster layout with 120o sectored cells, it can be easily understood that the mobile units in a particular sector of the center cell will receive co-channel interference from only two of the first-tier cochannel base stations, rather than from all six(Fig.2). Likewise, the base station in the center cell will receive co-channel interference from mobile units in only two of the co-channel cells. Hence the signal to interference ratio is now modified to

$$\frac{S}{I} = \frac{(\sqrt{3N})^{n}}{2}$$

Where the denominator has been reduced from 6 to 2 to account for the reduced number of interfering sources. For 60^0 it reduces to 1. For 60^0 $\frac{S}{I} = \frac{(\sqrt{3N})^n}{1}$

Now, the signal to interference ratio for a seven-cell cluster layout using 120o sectored antennas can be found from equation above to be 23.4 dB which is a significant improvement over the Omni-directional case where the worst-case S/I is found to be 17 dB (assuming a path-loss exponent, n=4). Some cellular systems divide the cells into 60o sectors. Similar analysis can be performed on them as well.

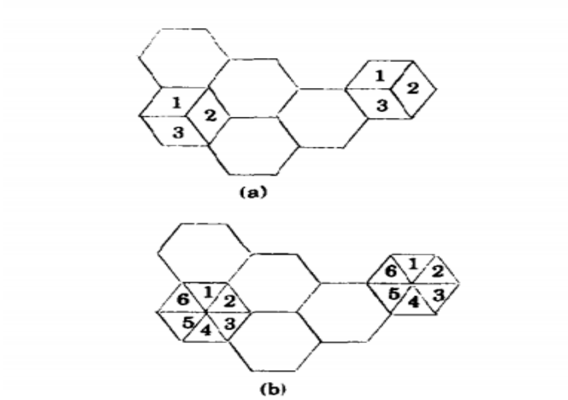


Figure 1 a) 120^0 Sectoring   b) 60^0 sectoring

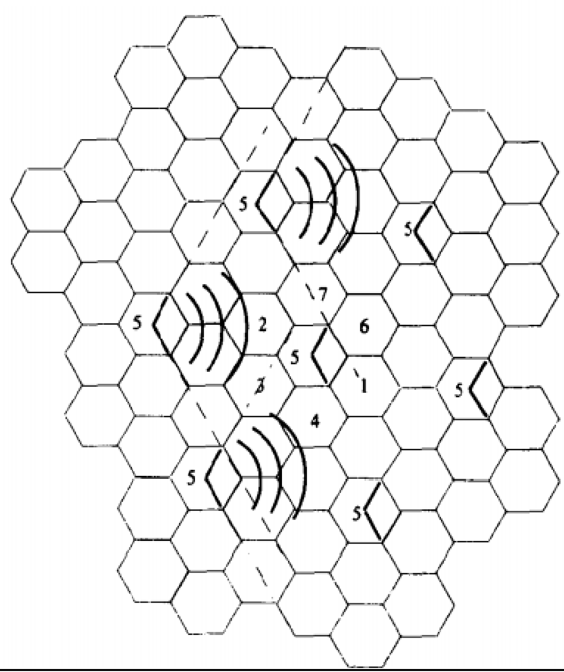
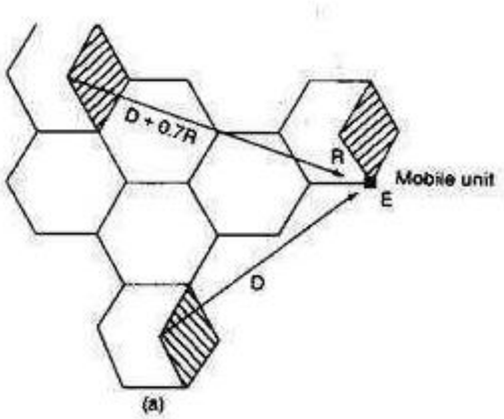


Figure 2 120^0 sectoring out of 6 co-channel cell only 2 are interfere



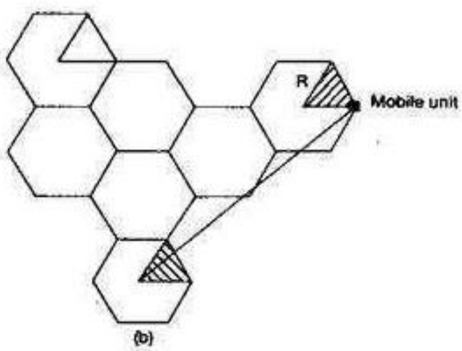


Fig.. Determination of S/I in a directional antenna system. (a)Worst case in a 120 directional Antenna system ; (b) worst case in a 60 directional antenna system)

Worst case S/I Ratio for 120^0 sectoring is given below

$$\frac{S}{I} = \frac{1}{(Q+0.7)^{-n} + Q^{-n}} \qquad [1]$$

Worst case S/I Ratio for 60^0 sectoring is given below

$$\frac{S}{I} = \frac{1}{(Q+0.7)^{-n}} \qquad [2]$$

IV) PRCEDURE

1. Take the user defined value for type of sectoring to be used
2. Declare n=4, find S/I and convert to db
3. **Estimate** S/I for ideal and worst case for 120^0 ,60^0 sectoring and omni-directional system

method	N	S/I ideal(db)	S/I worst case(db)
Without sectoring	4		
120^0 sectoring	4		
60^0 sectoring	4		
Without sectoring	7		
120^0 sectoring	7		
60^0 sectoring	7		

V) <u>PROGRAM:</u>

VI) <u>CONCLUSION</u>

EXPERIMENT NO.3

NAME OF THE EXPERIMENT: Free space propagation model

I) AIM: To observe the effect of **Free space propagation model** on coverage distance

II) APPARATUS :

4. PC
5. Printer
6. MATLAB software

III) THEORY

In the absence of any reflections or multipath, radio wave propagation can be modeled using the free space propagation model which says:

$$S_r = S_t G_t G_r \left(\frac{\lambda}{4\pi \mathrm{d}}\right)^2$$

where:

- S_r is Received Power in Watts
- S_t is Transmitted Power in Watts
- G_t is Transmit Antenna Gain (isotropic)
- G_t is Receive Antenna Gain (isotropic)
- l is Wavelength
- d is Tx/Rx Separation in same units as wavelength

Alternatively we can express equation 1 in dB units by taking 10 log $_{10}$ of both sides to obtain:

$$S_r(dBW) = S_t(dBW) + G_t(dBi) + G_r(dBi) + 20\log_{10}\left(\frac{\lambda}{4\pi}\right) - 20\log_{10}(d)$$

(equation 2)

The last two terms of equation 2 combined are called Path Loss (PL) for free space propagation. This is the channel's loss in going from the transmitter to the receiver expressed in dB. The first two right hand terms combined is called Effective Isotropic Radiated Power or EIRP. EIRP is the equivalent transmitter power required if an isotropic (0 dBi) antenna were used. Using these definitions, we obtain equation 3 where for free space propagation; PL (dB) = -20 $\log_{10}$ (λ / 4pd)

$S_r(dBW) = EIRP(dBW) + G_r(dBi) - PL(dB)$ (equation 3)

For non-free space propagation conditions, PL might be described by PL=A+B log $_{10}$ (R)ray propagation model.

IV) PROGRAM:

V) PROCEDURE :

1. Write a program to calculate path loss in free space propagation at 3Mz,30MZ,300Mhz
2. Plot path loss Vs distance and three frequency
3. Run program observe output
4. Take printout of program and graph

VI) OUTPUT: Observe the output of input and output waveform

VII) CONCLUSION:

Path loss increases with distances and decrease with increase in frequency

VIII) SAMPLE EXPERT VIVA VOCE QUESTION

1. What is path loss
2. What is relation dbm and dbw
3. What is relation of distance d with power transmitted in free space propagation
4. What is relation of distance d with power transmitted in two ray model
5. List other propagation model

EXPERIMENT NO : 4

NAME OF THE EXPERIMENT: Effect of incidence angle on reflection coefficient

I) AIM: To observe the effect of incidence angle on reflection coefficient

II) APPARATUS:

1. PC
2. Printer
3. Matlab

III) THEORY

When a radio wave propagating in one medium impinges upon another medium having different electrical properties, the wave is partially reflected and partially transmitted. If the plane wave is incident on a perfect dielectric, part of the energy is transmitted into the second medium and part of the energy is reflected back into the first medium, and there is no loss of energy in absorption. If the second medium is a perfect conductor, then all incident energy is reflected back into the first medium without loss of energy. The electric field intensity of the reflected and transmitted waves may be related to the incident wave in the medium of origin through the Fresnel reflection coefficient (τ). The reflection coefficient is a function of' the material properties, and generally depends on the wave polarization, angle of incidence, and the frequency of the propagating wave. In general, electromagnetic waves are polarized, meaning they have instantaneous electric field components in orthogonal directions in space. A polarized wave may be mathematically represented as the sum of two spatially orthogonal components, such as vertical and horizontal, or left-hand or right-hand circularly polarized components. For an arbitrary polarization, superposition may be used to compute the reflected fields from a reflecting surface.

Figure 3.1 shows an electromagnetic wave incident at an angle Θ_i with the plane of the boundary between two dielectric media. As shown in the figure, part of the energy is reflected back to the first media at an angle Θ_r and part of the energy is transmitted (refracted) into the second media at an angle Θ_t .The nature of reflection varies with the direction of polarization of the E-field. The behavior for arbitrary directions of polarization can be studied by considering the two distinct cases shown in Figure3.1. The plane of incidence is defined as the plane containing the incident, reflected, and transmitted rays . In Figure 3.a, the E-field polarization is parallel with the plane of incidence (that is, the E-field has a vertical polarization, or normal component, with respect to the reflecting surface) and in Figure 3.4b, the E-field polarization is perpendicular to the plane of incidence (that is, the incident E-field is pointing out of the page towards the reader, and is perpendicular to the page and parallel to the reflecting surface).

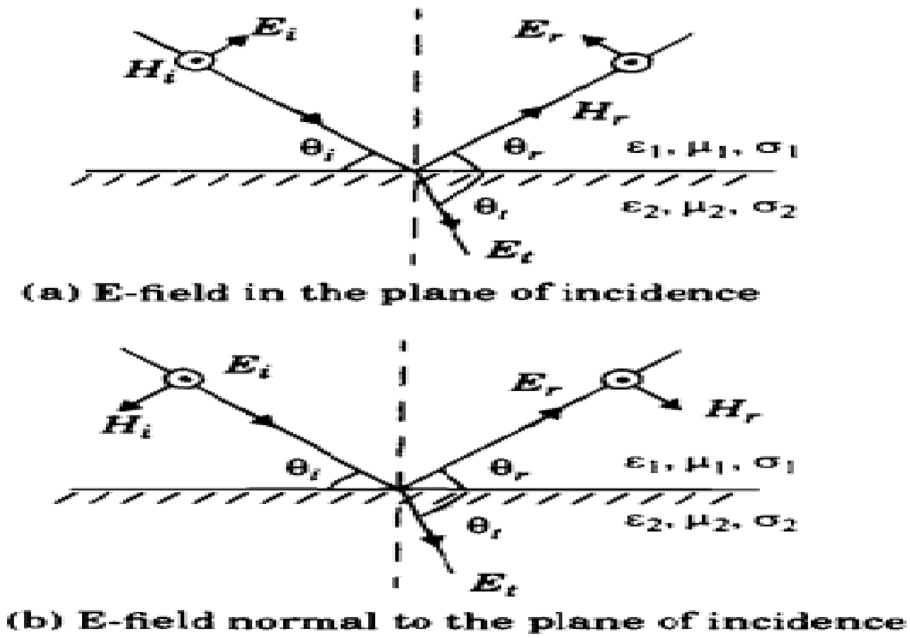
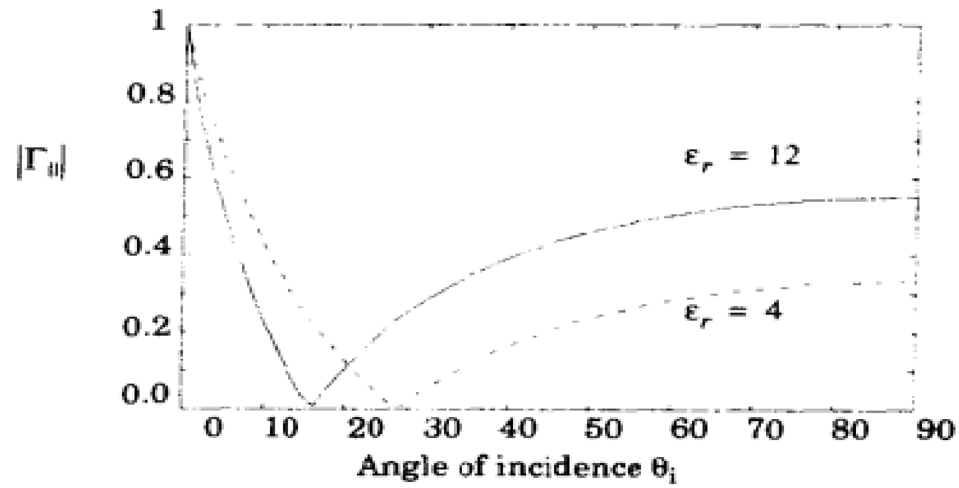


Fig 3.1 Geometry for calculating the reflection coefficients between two dielectrics.

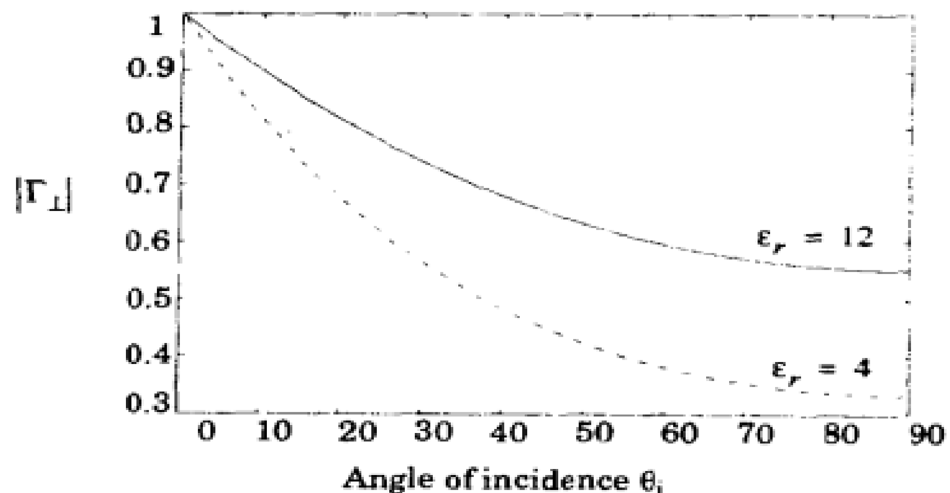
the reflection coefficients for the two cases of vertical and horizontal polarization can be given as

$$\Gamma_{\parallel} = \frac{-\varepsilon_r \sin\theta_i + \sqrt{\varepsilon_r - \cos^2\theta_i}}{\varepsilon_r \sin\theta_i + \sqrt{\varepsilon_r - \cos^2\theta_i}}$$

$$\Gamma_{\perp} = \frac{\sin\theta_i - \sqrt{\varepsilon_r - \cos^2\theta_i}}{\sin\theta_i + \sqrt{\varepsilon_r - \cos^2\theta_i}}$$



Parallel polarization (E-field in plane of incidence)



Perpendicular polarization (E-field not in plane of incidence)

IV) PROCEDURE:

1. Write program to a plot of the reflection coefficient for both horizontal and vertical polarization as a function of the incident angle for the case when a wave propagates in free space $\epsilon_r = 1$) and the reflection surface has (a) $\epsilon_r = 4$, and $\epsilon_r = 12$.
2. Run program take printout.

V) PROGRAM:

VI) CONCLUSION:

EXPERIMENT NO: 5

NAME OF THE EXPERIMENT: Doppler Effect

I) AIM: To observe the effect of velocity and direction of arrival of a vehicle on Doppler Frequency.

Transmitter which radiates a carrier frequency of 1850 MHZ for a vehicle moving 60 mph, calculate receive carrier frequency if the mobile is moving

1. Directly towards the transmitter
2. Directly towards away from the transmitter
3. In the direction which is perpendicular to the direction of arrival of the transmitted signal

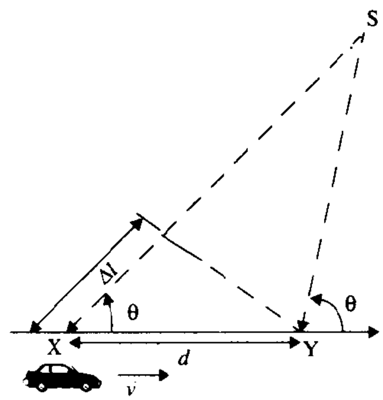
II) APPARATUS:

4. PC
5. Printer
6. Matlab

III) THEORY

The relative motion between the base station and the mobile results in random frequency modulation due to different doppler shifts on each of the multipath components.

apparent received frequency is decreased). As shown in section 4.7.1, multipath components from a CW signal which arrive from different directions contribute to Doppler spreading of the received signal, thus increasing the signal bandwidth.



Consider a mobile moving at a constant velocity v, along a path segment having length d between points X and Y, while it receives signals from a remote source S, as illustrated in Figure 4.1. The difference in path lengths traveled by the wave from source S to the mobile at points X and Y is $\Delta l = d\cos\theta = v\Delta t\cos\theta$, where Δt is the time required for the mobile to travel from X to Y, and θ is assumed to be the same at points X and Y since the source is assumed to be very far away. The phase change in the received signal due to the difference in path lengths is therefore

$$\Delta\phi = \frac{2\pi\Delta l}{\lambda} = \frac{2\pi v\Delta t}{\lambda}\cos\theta \tag{4.1}$$

and hence the apparent change in frequency, or Doppler shift, is given by f_d, where

$$f_d = \frac{1}{2\pi}\cdot\frac{\Delta\phi}{\Delta t} = \frac{v}{\lambda}\cdot\cos\theta \tag{4.2}$$

Equation (4.2) relates the Doppler shift to the mobile velocity and the spatial angle between the direction of motion of the mobile and the direction of arrival of the wave. It can be seen from equation (4.2) that if the mobile is moving toward the direction of arrival of the wave, the Doppler shift is positive (i.e., the apparent received frequency is increased), and if the mobile is moving away from the direction of arrival of the wave, the Doppler shift is negative (i.e. the

IV) PROCEDURE :

3. Write matlab program for finding Doppler shift.
4. Run program take printout.

V) PROGRAMM:

VI) CONCLUSION:

If the mobile is moving in the direction of arrival of the wave Doppler shift is positive. The mobile is moving away from the direction of the arrival wave Doppler shift is negative. Multipath components from CW signal which arrive from different directions contribute to Doppler spreading of the received signal thus increasing bandwidth.

VII) SAMPLE EXPERT VIVA VOCE QUESTION

1. What is Doppler Effect?
2. What are different types of small scale fading?
3. What are factors influencing small scale fading

EXPERIMENT NO : 6

NAME OF THE EXPERIMENT: Generation of walsh code

I) AIM: To generate Walsh Codes using Hadamard Matrix

II) APPARATUS :

1. PC
2. Printer
3. Matlab

III) THEORY

Definition: A Hadamard matrix H of order n is an n × n matrix of 1s and -1s in which $HH^T = nI_n$. (I_n is the n×n identify matrix.) Equivalently, a Hadamard matrix is an n×n matrix of 1s and -1s in which any two distinct rows agree in exactly n/2 positions (and thus disagree in exactly n/2 positions.) With this definition, the entries of the matrix don't need to be 1s and -1s. They could be chosen from {red, green} or {0,1}.

A Hadamard matrix can exist only if n is 1, 2, or a multiple of 4.

The next matrices are formed iteratively using

The first matrix in a Hadamard transform is

$$H1 = \begin{pmatrix} 0 & 0 \\ 0 & 1 \end{pmatrix}$$

The next matrices are formed iteratively using

$$H_{N+1} = \begin{pmatrix} H_N & H_N \\ H_N & \overline{H}_N \end{pmatrix}$$

Example :

$$H_2 = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$$

$$H_4 = \left[\begin{array}{cc|cc} 1 & 1 & 1 & 1 \\ 1 & -1 & 1 & -1 \\ \hline 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \end{array}\right]$$

$$H_8 = \left[\begin{array}{cccc|cccc} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 \\ 1 & 1 & -1 & -1 & 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 \\ \hline 1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 \\ 1 & -1 & 1 & -1 & -1 & 1 & -1 & 1 \\ 1 & 1 & -1 & -1 & -1 & -1 & 1 & 1 \\ 1 & -1 & -1 & 1 & -1 & 1 & 1 & -1 \end{array}\right]$$

$$H_{16} = \left[\begin{array}{cccccccc|cccccccc} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 \\ 1 & 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 \\ 1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 & 1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 \\ 1 & -1 & 1 & -1 & -1 & 1 & -1 & 1 & 1 & -1 & 1 & -1 & -1 & 1 & -1 & 1 \\ 1 & 1 & -1 & -1 & -1 & -1 & 1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 & 1 & 1 \\ 1 & -1 & -1 & 1 & -1 & 1 & 1 & -1 & 1 & -1 & -1 & 1 & -1 & 1 & 1 & -1 \\ \hline 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 \\ 1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 & 1 \\ 1 & 1 & -1 & -1 & 1 & 1 & -1 & -1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 & 1 \\ 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 & -1 & 1 & 1 & -1 & -1 & 1 & 1 & -1 \\ 1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & 1 & 1 & 1 & 1 \\ 1 & -1 & 1 & -1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 & 1 & 1 & -1 & 1 & -1 \\ 1 & 1 & -1 & -1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 & 1 & 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 & -1 & 1 & 1 & -1 & -1 & 1 & 1 & -1 & 1 & -1 & -1 & 1 \end{array}\right]$$

CDMA used another type of code called Walsh Hadamard Code. In IS-95 CDMA, 64 Walsh codes are used per base station. This enables to create 64 separate channels per base stations (i.e. a base station can handle maximum 64 unique users at a given time).In CDMA-2000 standard, 256 Walsh codes are used to handle maximum 256 unique users under a base.

Walsh codes are created using Hadamard Matrix and transform. The codes under a family of Walsh codes, posses a beautiful property of being orthogonal to each other.

Each row of a Hadamard matrix represent a unique Walsh code and all the Walsh codes in a given matrices are orthogonal. The length of the row of the matrix (number of columns otherwise) is the code-length of the Walsh codes. To get a 64-Walsh code matrix we need to transform the matrices till H8 (this matrix contains 64 rows – representing 64 walsh codes and each code is of 64 bits length).

Walsh codes posses excellent cross-correlation property (cross correlation of one Walsh code with another is always zero) therefore possess excellent orthogonality property. The auto-correlation property of Walsh code is very poor and so it is used only in synchronous CDMA networks, which maintains a synchronizing mechanism to identify the starting of the codeword.

Actually in IS-95, out of the 64 available Walsh codes, Walsh code 0 is reserved for pilot channel, 1 to 7 are assigned for synch channel and paging channels and the remaining 8-63 are assigned for users (traffic channel).

IV) PROGRAM

V) CONCLUSION :

Walsh codes are orthogonal codes and when used in synchronous CDMA-. In IS -95, out of the 64 available Walsh codes, Walsh code 0 is reserved for pilot channel, 1 to 7 are assigned for synch channel and paging channels and the remaining 8-63 are assigned for users

VI) SAMPLE EXPERT VIVA-VOCE QUESTIONS:

1. How walsh code are generated ?
2. What is role of walsh code in CDMA ?
3. What do you mean by orthogonal code?
4. Explain mapping of orthogonal code with CDMA channel

EXPERIMENT NO: 7

NAME OF THE EXPERIMENT: Generation of PN sequences

I) AIM: To generate Pseudo noise code used in a CDMA system Matlab

II) APPARATUS:

1. PC
2. Printer
3. Matlab

III THEORY

PN sequence is widely used in CDMA systems for the following reasons.
• spread the bandwidth of baseband modulated signal to the much larger bandwidth before transmission
• to distinguish between different users by allocating unique PN sequences to them.

PN sequence stands for Pseudorandom Noise Sequence. Though the name suggests they are random sequences; but they are not random. PN sequences are deterministic and periodic in nature. The same pattern repeats after some duration.

Following are important properties of a PN sequence.
• Relative frequencies of one and zero are each equal to one half.
• For 1s and 0s; half of all run lengths are of length 1; 1/4 are of length 2;1/8 are of length 3 and so on.
• If new sequence is generated by shifting original sequence by nonzero elements than equal number of agreements and also disagreements exist between these two sequences.

PN sequences are generated by combining outputs of feedback shift registers.

LFSR (Linear Feedback Shift Register)

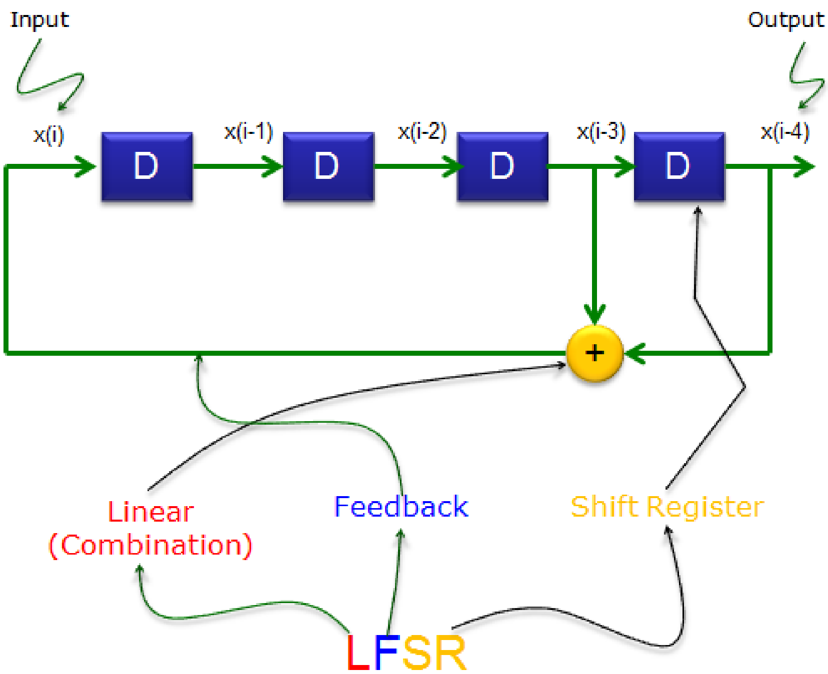
LFSR is a shift register circuit in which two or more outputs from intermediate steps get linearly combined and feedback to input value. That's why it is called Linear Feedback Shift Register as illustrated below.

This circuit has following properties:

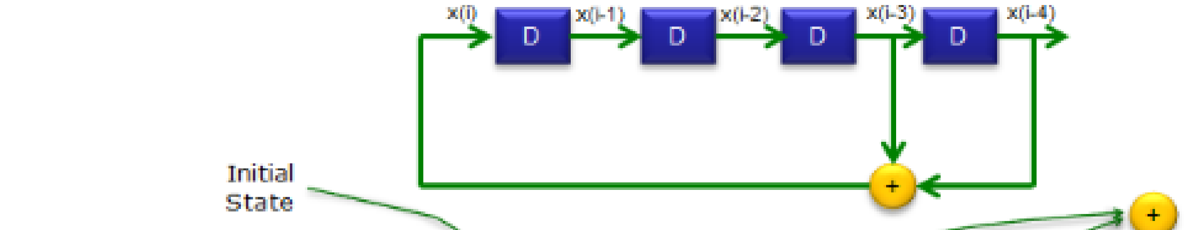
- If the initial states is same, you will always get the same output sequence (meaning Output sequence is deterministic)

- Output sequence tend to be like random sequence (Pseudo random)
- After a certain number of iteration, you will get the states values which is same as the initial states. (The maximum interval can be calculated by (2^n - 1), where n is the number of shift register.)

Due to the properties listed above, LFSR is mainly used to generate PN sequence (Pseudo Noise sequence).

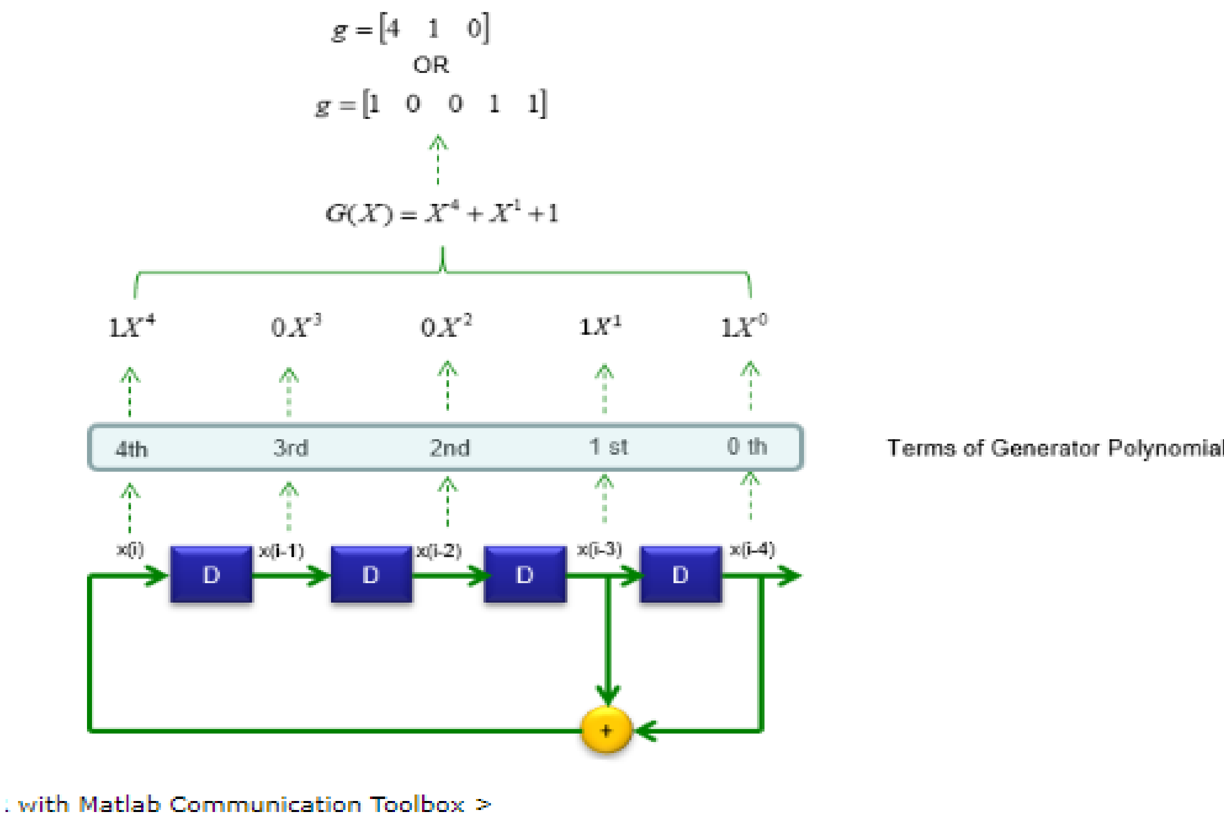


States transition of each iterations for the circuit in this example is shown below. From this table, you may notice all the properties listed above.



State	X(i-1)	X(i-2)	X(i-3)	X(i-4)	X(i)
0	1	1	1	1	0
1	0	1	1	1	0
2	0	0	1	1	0
3	0	0	0	1	1
4	1	0	0	0	0
5	0	1	0	0	0
6	0	0	1	0	1
7	1	0	0	1	1
8	1	1	0	0	0
9	0	1	1	0	1
10	1	0	1	1	0
11	0	1	0	1	1
12	1	0	1	0	1
13	1	1	0	1	1
14	1	1	1	0	1
15	1	1	1	1	0

In many publication, you would see this circuit is represented as a polynomial. But you may find it difficult to correlate between the real circuit and the generator polynomial. Following illustration would help you understand the meaning of the generator polynomial.



IV) PROGRAM

IV) PROCEDURE:

1. Take input sequence from the user.
2. Perform the logic according to the given PN code sequence generator.
3. Display the PN code.

V) CONCLUSION:

VI) SAMPLE EXPERT VIVA-VOCE QUESTIONS:

1. What is CDMA?
2. How PN sequence code generated?
3. What are specification of IS- 95?

EXPERIMENT NO: 8

NAME OF THE EXPERIMENT: Multiple input multiple output system

I) AIM: To plot channel capacity versus SNR for different MIMO systems

II) APPARATUS:

1. PC
2. Printer
3. Matlab

III) THEORY:

MIMO systems are systems with *Multiple Element Antennas* (MEAs) at *both* link ends. Recent years have witnessed an explosive growth of interest in studying and using multiple antenna techniques for wireless communication systems. Such a trend is motivated by the fact that several of the specifications foreseen for future wireless systems appear to be difficult, if not impossible, to fulfill with conventional single antenna systems.

It is widely accepted that multiple antennas have the potential to increase the achievable data throughput, to enhance link quality (BER, QoS), and to increase cell coverage and network capacity, among others. Such a promising array of enhancements has contributed to speeding up the development in the field, both at academic levels, where countless techniques are developed, and in the industry, where solutions based on these techniques are being rapidly adopted in real systems. Multiple transmit and receive antennas can be combined with various
Multiple access techniques such as TDMA, CDMA, and OFDM to improve the capacity and reliability of communications. Multiple-input multiple-output (MIMO) communication systems are regarded as an effective solution for future high-performance wireless networks. The use of multiple antennas at transmitter and receiver, popularly known as MIMO, is a promising cost-effective technology that offers substantial leverages in making the anticipated 1-Gbpswireless links a reality.

Overview of MIMO Technology

Depending on the geometry of the employed antenna array, two basic multiantenna approaches can be considered: a beamforming approach for closely separated antenna elements (inter element separation is at most λ/2, where λ is the carrier wavelength) or a diversity approach for widely separated antenna elements (typical inter element spacing is at least a few λ).
We will explore the latter approach where the fading processes associated
With any two possible transmit-receive antenna pair can be assumed to be independent. The fact that a MIMO system consists of a number of uncorrelated concurrent channels has been exploited from two different perspectives. First, from a pure diversity standpoint, one can enhance the fading statistics of the received signal by virtue of the multiple available replicas being affected by

independent fading channels. By sending the same signal through parallel and independent fading channels, the effects of multipath fading can be greatly reduced, decreasing the outage probability and hence improving the reliability of the communication link. In the second approach, referred to as spatial multiplexing, different information streams are transmitted on parallel spatial channels associated with the transmit antennas. This could be seen as a very effective method to increase spectral efficiency. In order to be able to separate
the individual streams, the receiver has to be equipped with at least as many receive antennas as the number of parallel channels generated by the transmitter in general. For a given multiple antenna configuration, one may be interested in finding out which approach would provide the best possible or desired performance.

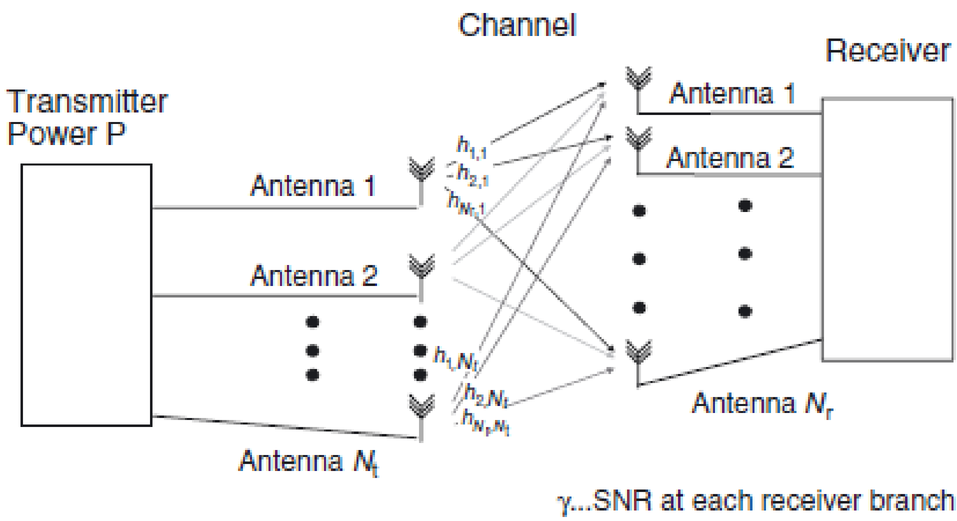


Fig: Block Diagram of Multiple Input and Multiple Output

IV)PROGRAM:

V) <u>CONCLUSION:</u>

In MIMO multipath fading can be greatly reduced, decreasing the outage probability and hence improving the reliability of the communication link

VI) <u>SAMPLE EXPERT VIVA-VOCE QUESTIONS:</u>

1. What is MIMO system?
2. What are advantages of MIMO
3. Explain types of diversity techniques?

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