MICROWAVE ANTENNA PATTERN WITH DIFFERENT PARAMETER EVALUATION IN MOBILE ENVIRONMENT

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ABSTRACT

Antenna is a "a metallic (usually) device used for radiating or receiving electromagnetic waves which acts as the transition region between free space and guiding structure like a transmission line in order to communicate even in a longer distance". Antenna pattern, antenna tilting, gain and antenna height all affect the cellular system design.
The antenna pattern can be omni directional, directional, or any shape in both the vertical and the horizon planes. The antenna patterns seen in cellular systems are different from the patterns seen in free space. If a mobile unit travels around a cell site in areas with many buildings, the Omni directional antenna will not duplicate the Omni pattern. In addition, if the front-to- back ratio of a directional antenna is found to be 20 dB in free space, it will be only 10 dB at the cell site. Antenna tilting can reduce the interference to the neighboring cells and enhance the weak spots in the cell. Also the height of the cell-site antenna can affect the area and shape of the coverage in the system.

Keywords: *Antenna Pattern, Antenna Tilting, Omni Directional Antenna, Cell Site*.

1. INTRODUCTION

Antenna plays an indispensable role in CMC system. The general block diagram of the cellular mobile communication system is shown in Figure 1. As all the communication system undergoes through various types of degradations, noise and interferences [1], it is necessary to have a general concept about these factors. These are also included.

Antenna pattern, antenna tilting, gain, antenna tilting, and antenna height all affect the cellular system design. The antenna pattern can be omni directional, directional, or any shape in both the vertical and the horizon planes. Antenna gain compensates for the transmitted power. Different antenna patterns and antenna gains at the cell site and at the mobile units would affect the system performance and so must be considered in the system design. Here we have considered about cell splitting, Sectorization, umbrella pattern of antenna system, and different types of mobile antenna for reducing interference.

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2. MICROWAVE ANTENNA

2.1. Microwave Antenna Location

Sometimes the reception is poor after the microwave antenna has been mounted on the antenna tower. A quick way to check the installation before making any other changes is to move the microwave antenna around within a 2 to 4 ft radius of the previous position and check the reception level. Surprisingly favorable results can be obtained immediately because multipart cancellation is avoided as a result of changing reflected paths at the receiving antenna [2]. Also, at any fixed microwave antenna location, the received signal level over a 24-hr time period varies.

2.2. Characteristics of Microwave Antennas

Microwave antennas can afford to concentrate their radiated power in a narrow beam because of the size of the antenna in comparison to the wavelength of the operating frequency; thus. High antenna gain is obviously desirable. Some of the more significant characteristics are discussed in the following paragraphs.

2.2.1. Beam width

The greater the size of the antenna, the narrower the beam width. Usually the beam width is specified by a half-poer (3 dB) beam width and is less than 100 at higher microwave frequencies. The beam width sometimes can be less than 1.0. The narrow beam can reduce the chances of interference from adjacent sources or objects such as adjacent antennas [3]. However, a narrow beam antenna requires a fair amount of mechanical stability for the beam to be aimed at a particular direction.

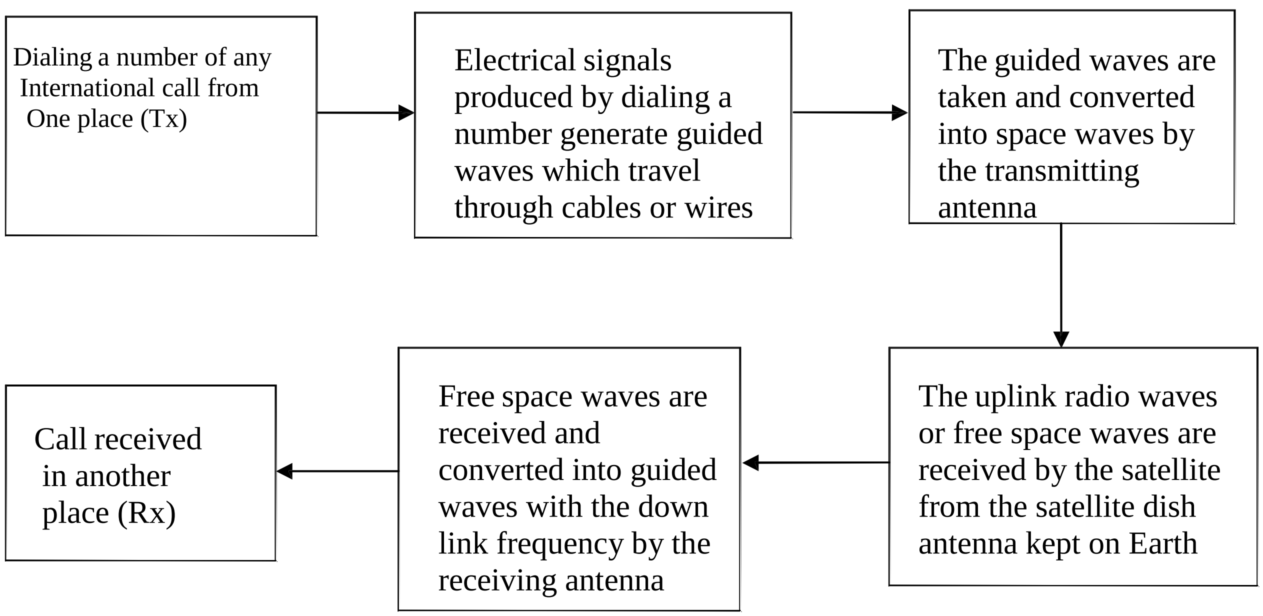


Figure 1. Block Diagram of Antenna System for Telephone and Mobile Communication

2.2.2. Side lobes

The side lobes of an antenna pattern would be the potential source of interference to other microwave paths or would reder the antenna vulnerable to receiving interference from other microwave paths. Front-to back ratio: This is defined as the ratio of the maximum gain in the forward direction to the maximum gain in the backward direction. The front-to-back ratio is usually in the range of 20 to 30 dB because of the requirement for isolating or protecting the main transmission beam from interference.

2.2.3. Repeater requirement

The front-to-back ratio is very critical in repeaters because the same signal frequencies are used in both directions at one site. An improper design can cause a pung-pong ringing type of oscillation from allow front-to-back ratio or from poor isolation between the transmitting port and receiving port of the repeater [4].

2.2.4. Site-side coupling loss

The coupling loss, in decibels, should be designed to be high as a result of the transmitting antenna carrying only the output signal and the receiving antenna receiving only the input signal.

If the transmitting and receiving antennas are installed side by side, the typical transmitter outputs are usually 60 dB higher than the receiver, input level. Longer link distance results in increased values. Therefore, the coupling losses must be high in order to avoid internal system interference. The space separation between to avoid internal system interference. The space separation between two antennas and the filter characteristics in the receiver can be combined with a given antenna pattern to achieve the high coupling loss.

2.2.5. Back-to back coupling

The back-to-back coupling loss also should be high (e.g., 60dB) between two antennas. Two antennas are installed back to back, one transmitting and one receiving. However, it is much easier to reach a high back-to-back coupling loss than a side-to- side coupling loss.

2.3. Polarization and Space Diversity in Microwave Antennas

2.3.1. Polarization

To reduce adjacent channel interference, microwave relay systems can interleave alternate radio-channel frequencies from a horizontal polarized wave to a vertical polarized wave. The same approach can be applied to the left-and right-handed circularly polarized waves, but the beam widths of antennas for this loss is defined as the ratio of the poor received in the desired polarization to the poor coupling into other polarization. The cross coupling required for one hop.

2.3.2. Space diversity

The two antennas separated vertically or horizontally can be used for a two-branch space-diversity arrangement. In a space-diversity receiver, the required reception level is relatively low so that the transmitted power on the end of the link can be reduced. This is also an effective method for increasing the coupling loss between the transmitting antenna and receiving antenna.

2.4. Types of Microwave-Link Antenna

Two kinds of antenna are used for microwave links

1. A parabolic dish, used for short-haul systems. Antennas sizes range form 1.5 m (5fg) to 3 m (10ft) in diameter.
2. A horn-reflector antenna, to trap the energy outward from the focal a. Good match–return loss 40-50 dB.

2.5. Installation of Microwave Antennas

A microwave antenna cannot be installed at any arbitrary location. Selection of an optimum position is very important. In many situations if we cannot move horizontally, we can move vertically. In a microwave-link setup, there are two fixed effective antenna heights, one at each end based on each reflection plane where the reflection point is incident on it. The gain of the received signal also relates to the two effective antenna heights if they are low. The antenna location can be move around to find the best reception level. Sometimes it is worthwhile to take time to search for the location that gives the best reception [5].

3. TYPES OF ANTENNA USED IN BS AND MS IN MOBILE COMMUNICATION

3.1. In MS (Mobile Station)

Omni-directional (monopole antenna):

It is used due to its broadband characteristics and simple construction, monopole antenna is used in the hand held unit (Mobile Station).A $\lambda/4$ monopole is very popular in mobile communication. Other alternatives of monopole antenna are loop antenna, microstrip antenna and spiral antenna etc.

3.2. In BS (Base Station)

Panel antenna:
i) Omni-directional
ii) Sectoral
Panel antenna = dipole array inside it and is covered with radome
Frequency range of population --- 1420 to 1530 MHz
Sectoral antenna operates in polarization diversity.

4. DESIGN OF ANTENNA

4.1. Design of an Omni Directional Antenna System

K = 7 cell pattern doesn't provide a sufficient frequency reuse distance separation even when an ideal condition of flat terrain is assumed. The worst case is at the location where the mobile unit would receive the weakest signal from its own cell site but strong interference from all interfering cell sites.

In the worst case the mobile unit is at the cell boundary (point X), as shown in the Figure 2. The distances from all six co channel interfering sites are also shown in the Figure 2: two distances of D-R and two distances of D + R. following the mobile propagation rule of 40 dB/decade, we obtain $C \propto R^{-4}$, $I \propto D^{-4}$, then the carrier to interference ratio is:

$C/I = R^{-4} / 2(D-R)^{-4} + 2D^{-4} + 2(D+R)^{-4}$

$$= 1/2(q-1)^{-4} + 2q^{-4} + 2(q+1)^{-4} \qquad (1)$$

where q=D/R= co-channel reuse factor

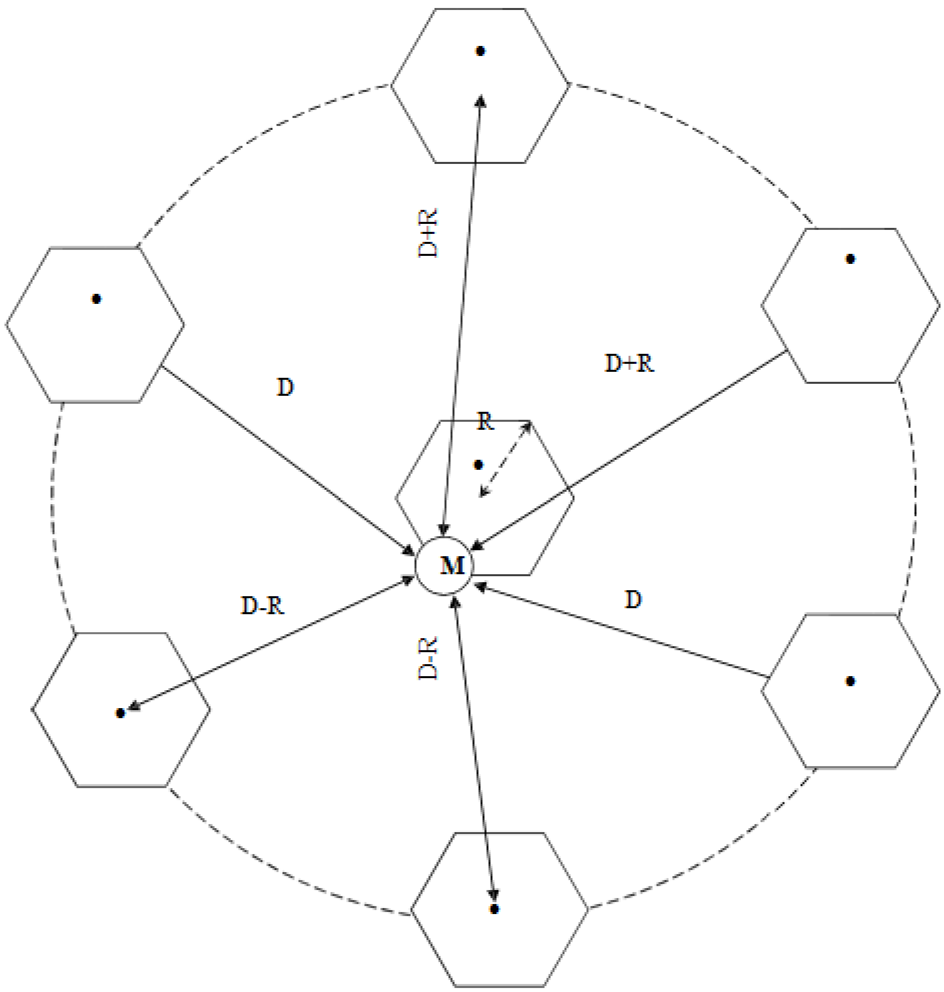


Figure 2. Illustration of 1st tier co-channel cells for a cluster size of N = 7

We may use the shortest distance D-R for all six interferer as a worst case then the above equation can be written as

$$C/I = R^{-4} / 6(D-R)^{-4} \qquad (2)$$

here for K = 7, we have $q = D/R = 3\sqrt{K} = \sqrt{3*7} = 4.6$

C/I= 17dB from equation 1and for the worst case from equation 2, C/I=14.47dB.

In reality because of the imperfect site location and the rolling nature of the terrain configuration, the C/I received is always worse than 17 dB or could be 14 dB and lower. Such an instance can easily occur in a heavy traffic situation. Therefore the system must be designed around C/I of worst case. In that case the co channel interference factor of q= 4.6 is in-sufficient (i.e. reuse factor = K = 7).

Therefore in the omni-directional cell system, K = 9 or K =12 would be a correct choice. Then the value of q is:

$Q=D/R=\sqrt{3K}$

At K = 9, q = 5.196
At K = 12, q = 6.0

Substituting this value in equation 1 we obtain

C/I = 84.5 = 19.25 dB ----------- for K = 9
C/ I = 179.33 = 22.54 dB -------- for K = 12

Substituting this value in equation 2 we obtain

C/I = 51.67 = 17.133 dB -------- for K = 9
C/ I = 104.167 = 20.177 dB ---- for K = 12

The K = 9 and K = 12 cell pattern are used when the traffic is light. Each cell covers an adequate area with adequate numbers of channel to handle traffic. These patterns are not valid for the case when there is a huge traffic.

4.2. Design of a Directional Antenna System
When the cell traffic begins to increase, we need to use the frequency spectrum efficiently and avoid increasing the number of cells K in a 7-cell frequency reuse pattern. When K increases the number of frequency channels assigned in a cell must become smaller (assuming a total allocated channel divided by K) and the efficiency of applying the frequency reuse scheme decreases.

Instead of increasing the number K in a set of cells, let us keep K = 7 and introduce a directional antenna arrangement. The co-channel interference can be reduced by using directional antennas. This means that each cell is divided into 3 or 6 sectors and uses 3 or 6 directional antennas at a base station. Each sector is assigned a set of frequencies (channels). The interference between two co-channel cells decreases as shown below:

4.2.1. For K=7 (i.e. q = 4.6)

a) Three sector case
The three-sector case is shown in fig. To illustrate the worst-case situation, two co- channel cells are shown in Figure 3. The mobile unit at position E will experience grater interference in the lower shaded cell sector site. This is because the mobile receiver receives the weakest signal from its own cell but fairly strong interference from the interfering cell.
In a three sector case, the interference is effective only in one direction because the front to back ratio of a cell site directional antenna is at least 10 dB or more in a mobile radio environment. The worst-case co-channel interference in a directional antenna sectors in which interference occurs may be calculated. Because of the use of directional antennas, the number of principal interferers is reduced from 6 to 2. The worst case of C/I occurs when the mobile unit is at position E, at which point the distance between the mobile unit and the two interfering antennas is roughly D + R/2, however, C/I can be calculated more precisely as follows. The value of C/I can be obtained by the following expression (assuming that the worst case is at position E at which the distance from the two interferers are D + 0.7 and D).

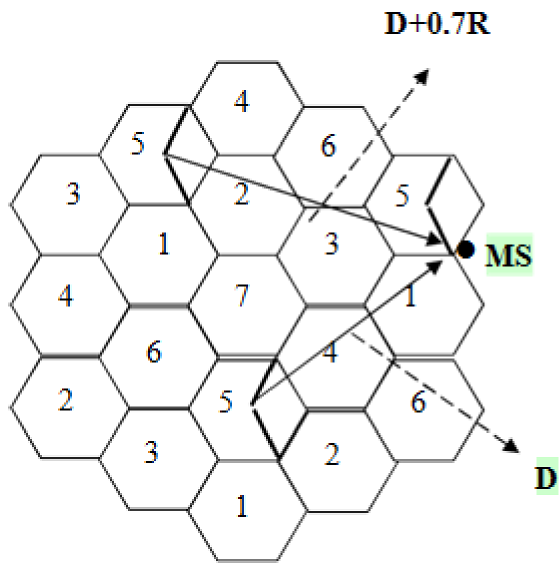


Figure 3. Sector Case for K = 7

C/I (worst case) = $R^{-4}/ (D+0.7R)^{-4}+D^{-4} = 1/ (q+0.7)^{-4}+q^{-4}$

Let q=4.6 then

C/I(worstcase)=285=24.5dB (3)

The C/I received by a mobile unit from the 120^{O} directional antennas sector system expressed in equation 3 greatly exceeds 18 dB in a worst case equation 3 shows that using directional antenna sectors can improve the signal to interference ratio. That is reusing the co-channel interference. However in reality the C/I could be 6 dB weaker than in equation 3 in a heavily traffic area as a result of irregular terrain contour and imperfect site locations. The remaining 18.5 dB is still adequate.

b) Six sector case

We may also divide a cell into 6 sectors by using six 60^{O} beam directional antenna. In this case only one instance of interference can occur in each sector. Therefore C/I ratio in this case is

$C/I=R^{-4}/(D+0.7R)^{-4}=(q+0.7)^{4}$ (4)

For q = 4.6, equation (2) can be given as

C/I = 794 = 29dB

Which shows a further reduction of co-channel interference. If we use the same argument as we did for equation 3 and subtract 6 dB from the result of equation 4 the remaining 23 dB is still more than adequate. When heavy traffic occurs, the 60^{O} sector configuration can be used to reduce co-channel interference. However as fewer channels are generally allowed in a 60^{O} sector and the trunking efficiency decreases. In certain cases more available channel could be assigned in a 60^{O} sector.

4.2.2. K=4 (i.e. q = 3.46)

a) Three sector case

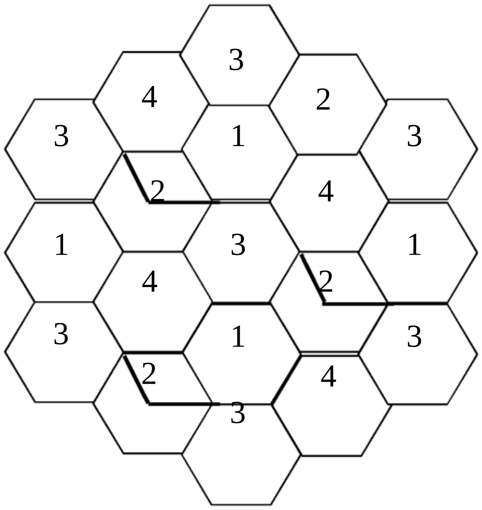


Figure 4. Sector Case for K = 4

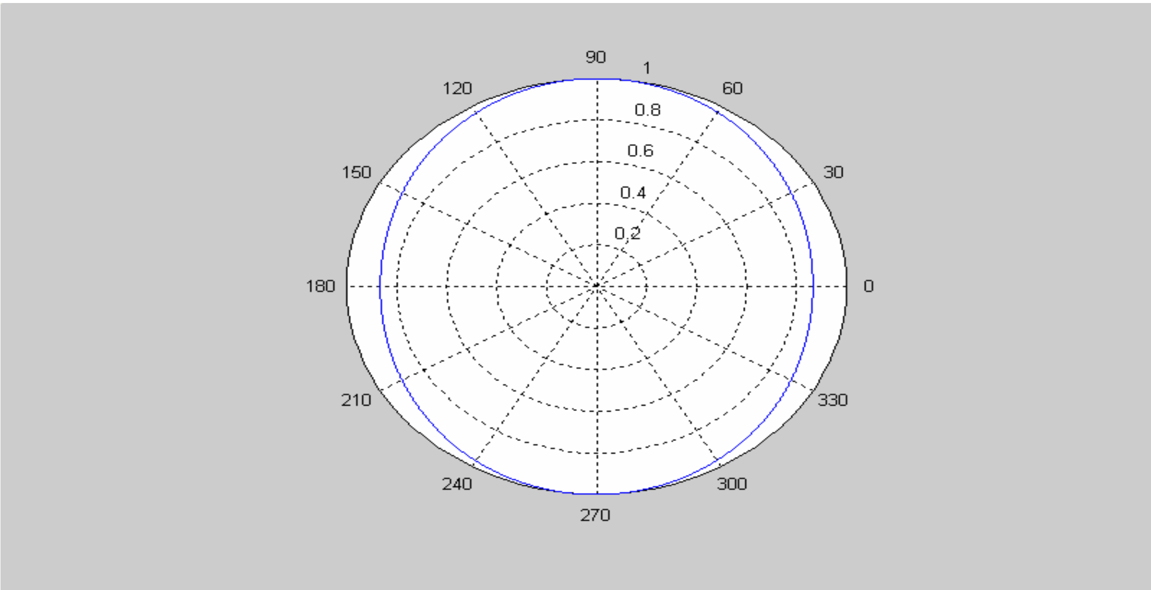
C/I (worst case)=1/(q+0.7)$^{-4}$=97=20dB

But after subtracting 6 dB for the same reason, we get only 14 dB which is within an unacceptable range.

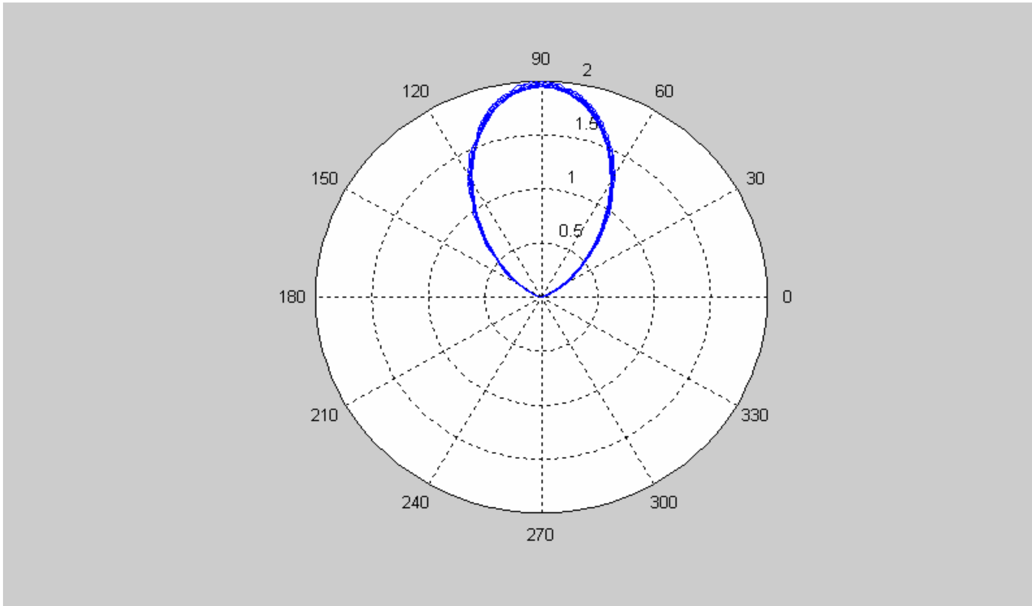
b) Six sector case
C/I (worst case)=1/(q+1)$^{-4}$=359.5=27dB
and after subtracting 6 dB, we get 21 dB which is still within the acceptable range.

5. SIMULATION USING MATLAB

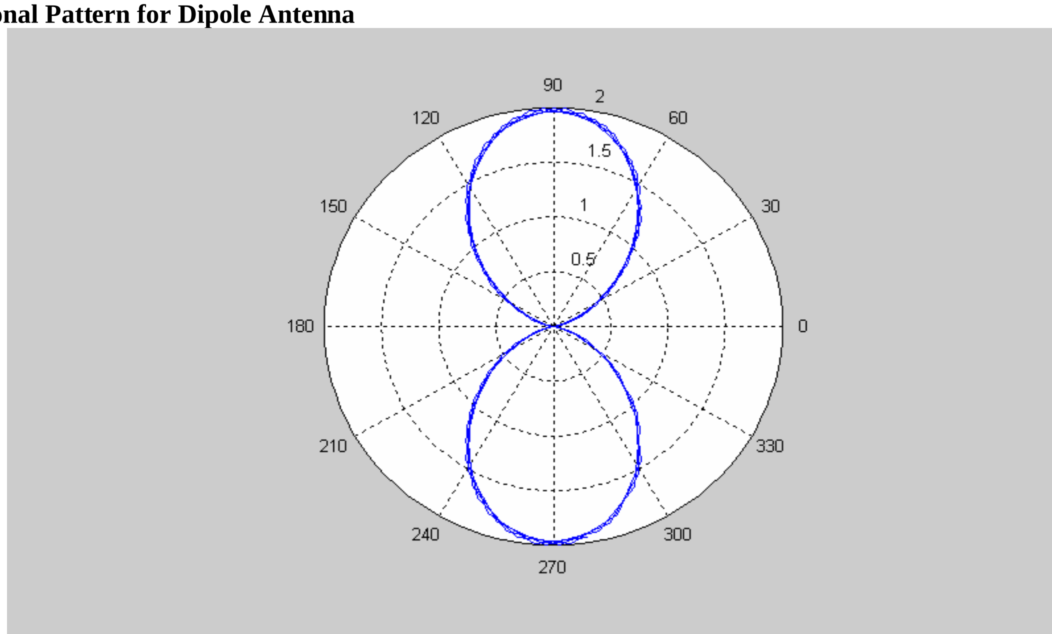
Omni Directional Pattern



Directional Pattern



Directional Pattern for Dipole Antenna



6. CONCLUSION

The research study in general system in cellular mobile communication was done. Various patterns of antenna radiation were obtained. Also different calculations regarding the channel capacity, antenna gain, and transmitted power Vs distance were calculated using the C-programming language. The presuming analysis about the different schemes such as improving signal quality and quantity aspects and also the reliability of the mobile system were done.

7. REFERENCES

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