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# Comparison of Various Techniques for Suppression or Cancellation of Co Channel Interference in GSM

P. Sumithabhashini and N.C. Eswar Reddy
Department of EEE, S.V. University, Tirupati, A.P., India

**Abstract:** The aim of this study, is to investigate and evaluate the performance of various techniques for suppression of co channel interference in GSM. In mobile communication networks, the system capacity is often limited by co channel interference because of the surrounding cells using the same carrier frequency. Therefore, to cancel or suppress co channel interference, some methods and algorithms are proposed. These methods are, optimum distribution of the transmitter power, lowering the antenna height, joint demodulation of co channel signals, dual antenna interference suppression technique, tilted base station antenna. In optimum distribution of transmitter powers, applied the complex algorithm and used regular and irregular model of the cellular system for simulation and assessed the algorithm efficiency. In lowering the antenna height, by half than the original, the efficiency is very much improved than with normal antenna height. In joint demodulation of the co channel signals, find's the dominant interferer (DI), which occurred because of the number of near by co channel interferers and its probability is investigated by network simulation and observerd the improved receiver performance. In dual antenna interference suppression technique, applied a filter based single antenna interference suppression for downlink GSM with 8PSK modulation by assuming the terminal is equipped with 2 antennas and evaluated the performance using correlation based spatial channel model and showed the potential of suppressing the co channel interference.

**Key words:** Comparison cancellation, interference, mobile communication, GSM

## INTRODUCTION

Interference is the major limiting factor in the performance of the cellular radio systems. Sources of interference include another mobile in the same cell, a call in progress in a neighboring cell, other base stations operating in the same frequency band, or any non linear system which inadvertently leaks energy into the cellular frequency band. Interferences on voice channels causes cross talk, where the subscriber hears interference in the background due to an undesired transmission on control channels, interference leads to missed and blocked calls due to errors in the digital signaling. Interference is more severe in urban areas, due to the greater RF noise floor and the large number of base stations and mobiles. This interference is major bottleneck in increasing capacity and is often responsible for dropped calls. In cellular mobile communication systems like the Global System for Mobile Communications (GSM). Co channel interference from cells using the same frequencies as the considered cell (frequency reuse)is an important capacity limiting factor.

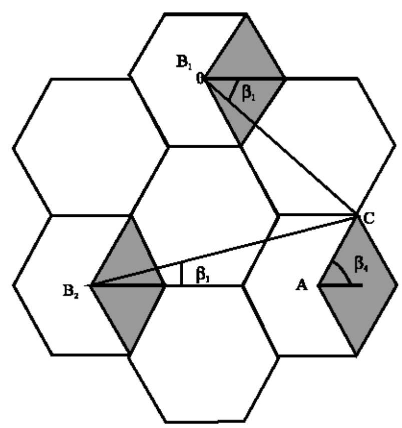


Fig. 1: Co channel interference between the cells. Where A, B: Co channel stations and C: Mobile unit

For systems with a low frequency reuse factor corresponding to high system capacity, cancellation of co channel interference at the receiver is necessary in order to obtain a good performance. Figure 1 shows the cochannel interference between the cells.

**Corresponding Author:** P. Sumithabhashini, Department of EEE, S.V. University, Tirupati, A.P., India

Here, are some of the methods which give solution to decrease or reject the co channel interference in downlink.

## REDUCTION OF CCI BY OPTIMUM DISTRIBUTION OF TRANSMISSION POWERS

**Introduction:** The growing demand for mobile communication system is to use the electromagnetic spectrum in the economic way. Problem of the shortage of spectrum arises when a large number of transmitters operating in a small region results in interference which decreases the system capacity (Zander, 1992). The technique used to reduce this CCI is by power control results to allow as many receivers as possible for satisfactory reception. The main idea of power control is to adjust the power of each transmitter for given channel allocation which minimizes the interference, to resolve these problems distribution of transmitter power of individual base stations is used.

**Description:** Definition of distribution of transmitter powers problem:

- Max Power $P_{max} = (p_{1max}, p_{2max} \cdots \cdots p_{Nmax})$
- Vector of power values $P_{op} = (p_{1op}, p_{2op}, \ldots p_{Nop})$ that minimize so called cost function is a solution of this optimization problem:

$$\text{Cost fuction } E = \sqrt{p_1 k_{12}} + \sqrt{p_1 k_{13}} + \sqrt{p_1 k_{14}} + \ldots\ldots + \sqrt{p_N k_{NN}}$$

$$E = \sum_{i=1}^{N} \sum^{N} \sqrt{P_i K_{ij}}$$

The expression to describes the optimization problem is:

$$E_{opt} = \min_{P_i} E(P_i)$$

The set of power values of individual base station is limited both from upper and lower limit. The analysis of optimization problem is nonlinear programming with limitations results from nonlinear character of some selected limitations. The numerical simulation experiment has realized basis of complex algorithum. The optimization algorithm complex is realized in 2 main stages, first, the nodes that make up set of acceptable solution are determined. The generation of co ordinate individual nodes is:

$$P_i = P + \rho_i (P_{max} - P_{min})$$

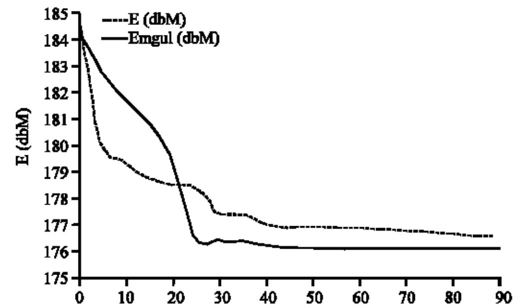


Fig. 2: Convergence rate of the complex algorithm to optimal solution for regular and irregular cellular system

where, $\rho_i$ is random numbers that are generated from range (0, 1).

The complex is produced on the basis of generated point set. If one of point do not meet all limitations then modify the location. To this end determine new point that meets all limitations. The point arises on the basis of centroid, which is described as:

$$P_c = \frac{1}{M} \sum_{\Omega} P_W$$

Where,

M = Number of all points that meet limitations.
$P_w$ = Point that meet all limitations.
Ω = The set of the point index.

The second phase of optimization is realized till the complex is obtained, in this chose the vertex, that is given the maximum value of the cost function and determined the centroid it is repeated till criterion of stop is met.

**Simulation and conclusion:** The elementary propagation model (EPM) is used for simulation. Experimental convergence rate of the algorithm to optimal solution for regular and irregular cellular system (Siwiak, 1995). Shape of curves show that in case of regular structure obtained more effective solution than irregular structure but it represents idealized situation. The convergence rate of complex algorithm to optimal solution for regular and irregular system is shown in Fig. 2.

In this method, identified the problem of reduction of CCI by optimal distribution of transmission powers with complex algorithm, which is appropriate for the planning energy balance of the cellular system.

## REDUCTION OF COCHANNEL INTERFERENCE IN GSM BY LOWERING THE ANTENNA HIGHT

**Introduction:** This method is very effective for reducing the Co Channel interference (CCI) on fairly flat ground or in a valley situation.

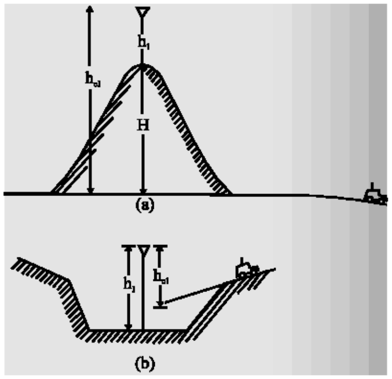


Fig. 3: (a) antenna on a high hill (b) in a valley

**Description:** Considering the 2 cases to reduce the CCI, which are on a high hill and in a valley shown in Fig. 3. On a high hill or a high spot:

- H = Height of a hill.
- $h_1$ = Height of an antenna.
- The effective antenna height is $h_{e1}=h_1+H$.
- Reducing the antenna height to half the modified height of antenna is $h_{1new} = h_{1/2}$.
- The effective antenna height after reducing the antenna height is: $h_{e2}=h_{1new}+H = 0.5h_1+H$.

The gain reduction is:

$$G = 20\log_{10}\left[\frac{h_{e2}}{h_{e1}}\right] = 20\log_{10}\left[\frac{1-0.5h_1}{h_1+H}\right]$$

If height of antenna is very less than the hill then:

$h_1 <<< H$ so $G=20\ \log_{10}1=0dB$

In a valley:

- $H_{e2}$=Effective antenna height as seen from mobile unit $H_{e2}$, h1 and $h_{e2}=2/3h_1$.
- Lowering the antenna height results $h_{1new} = 1/2h_1 = 0.5h_1$.
- Then the new effective antenna height is $h_{e2new} = 1/2h_1 - (h_1-h_{e2})=1/6h_1$.
- The gain reduction $G = 20\ \log h_{e2new}/he_2 = 20\log 1/4=-12dB$.

**Results:** From first case, proved that lowering the height of antenna on the hill does not reduce the power at either cell site or mobile unit (Lee, 1995). From second case, proved that the lowering the antenna height in a valley is very effective in reducing the power in a distant high elevation angle. To avoid this consider the area adjacent to the cell site antenna and its effective antenna is same as previous and gain is $G=20\ \log h_{e2}/h_1=20\ \log 0.5h_1/h_1=-6dB$, it is the power reduction caused by the decreasing the antenna height by half in a valley.

## CO CHANNEL INTERFERENCE REDUCTION IN GSM BY JOINT DEMODULATION OF CO CHANNEL SIGNALS

**Introduction:** Co channel interference is inherent problem due to necessity to reuse the same frequency after a certain reuse distance which leads to dominant interference (DI). Suppression of it provides capacity improvement for GSM. The interference reduction by joint detection requires only a single antenna receiver making it an attractive alternative especially in the mobile receiver. The aspects are divided into some basic divisions, which are first problem of co channel interference is introduced, which shows the probability of DI is high in GSM networks, second the receiver algorithm and channel estimator with DI identification and the performance is evaluated using a novel link simulator.

**Description:** To maximize the number of available traffic channels in a given geographical area results to cochannel interference and adjacent channel interference.

From Fig. 4 the signal to noise and interference ratio (SNIR) experienced by the receiver can be described by (Stuber, 2008).

$$SNIR = C / \sum_{i=1}^{N} I_i + N_{RX}$$

Where,

$C$ = Desired signal power.
$I_i$ = Power of incident cochannel signal.
$N_{rx}$ = Receiver noise power.

Dominant interferer likely exists in GSM, since the number of nearby cochannel interference is rather small, cancellation of it can improve the receiver performance but it dependent on the dominant to rest of interference ratioDIR:

$$DIR = I_{dom} / [\sum_{i=1}^{K} I_i - I_{dom} + \_ N_{RX}]$$

$I_{dom}$ = Dominant among all interfering signals i.e.
$I_{dom}$ = Max $(I_1, I_2, I_3 \ldots I_N)$.

The receiver algorithm considered is the co channel communication system model, which consists of N-transmitters with independent time varying channels, AWGN source, receiver filter, joint channel estimator and joint detector.

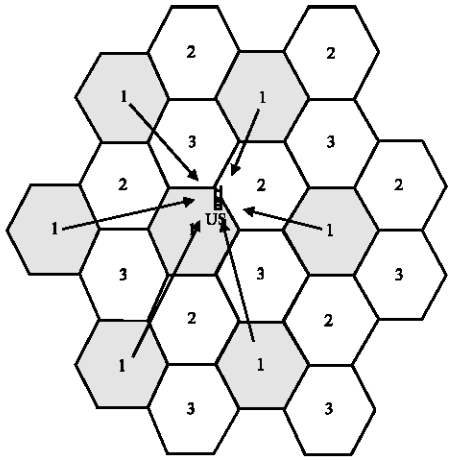


Fig. 4: Co channel interference problem in GSM, downlink direction and reuse pattern 3

**Results:** For performance analysis, used a novel link simulation system (Ranta and Pukkila, 1997) including 18 interferers, it tests and evaluated the interference cancellation gain, DI identification algorithm, required size of training sequence, effect of DIR on IC gain, effect of frequency hopping and compared the performance of different training sequence sets and concluded that CCI cancellation is feasible in the GSM system to enhance the performance of 1.3 dB using an alternative trading sequence set.

## DECOUPLED LINEAR CCI SUPPRESSION IN GSM USING DUAL ANTENNA

**Introduction:** In this, a filter based single antenna interference suppression technique is applied for downlink GSM by assuming the terminal is equipped with 2 antennas and evaluated the performance using a correlation based spatial channel model and showed the suppression of CCI even for high correlation factors.

**Description:** The structure of decoupled CCI suppression/ trellis based equalization scheme applied in GSM with a dual antenna. Hoeher *et al.* (2005) is shown in Fig. 5.

It consists of 2 stages. Linear filter suppresses the CCI and shorten the impulse response of desired user channel results states of non linear detector is reduced, hence, complexity reduces. Non linear detector suppresses the ISI caused by the desired user channel. Linear filter uses all its degrees of freedom to minimize CCI.

**Simulation:** For down link, one desired user and one or 2 co channel interferers in the system, adopted the block

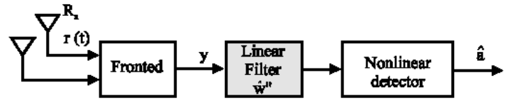


Fig. 5: Structure of decoupled CCI suppression equalization of GSM8PSK

fading assumption for simulation and fading between bursts are independent and co channel signals are independent. The channel estimates are obtained by correlating the retrieved signal with known training sequence code. In this assumed, receive correlation factors are zero and signal to noise ratio of 30dB, performance results for conventional single user MLSE with 512 states and one antenna are also included. At BER of 0.01, with one interferer in the system about 18dB gain is observed and compared to the conventional receiver. The 7.5 dB is obtained for 2 equally strong interferers results the performance of the receiver is same whether one or 2 strong interferers are present and investigated the effect of receive correlation factors on the performance of the decoupled linear CCI suppression.

**Conclusion:** Evaluated the performance using a correlation based spatial channel model and should the potential gain of suppressing the CI even for highly spatially correlated channel. It can be implemented further, if the phase angles of the correlation factors for the desired user and interferer are different it can be occurred if their signals arrive from different directions.

## EFFECT OF TILTED BASE STATION ANTENNA ON COCHANNEL INTERFERENCE REDUCTION IN CELLULAR COMMUNICATIONS

**Introduction:** The rapid development of mobile communications, cells in a cellular system tend to be much denser and the frequency reuse ratio grows up tremendously. The reduction of co channel interference between cellular co channel sites becomes a serious problem which has to be.solved using this method. In this, analyzed the cause of tilted base station antenna being of benefit to co channel interference reduction.

**Description:** Two cochannel stations A and B have 2 antennas A' and B' are faced to each other, with equal height ht and emits same power. A mobile unit called 'C' communicates with station A and is interfased by the cochannel station B. Shown in Fig. 1.

The carrier to interference ratio of mobile unit 'C' is written as (Stutzman *et al.*, 1981):

$$\frac{C}{I} = \left[\frac{B'C}{A'C}\right]^4 [F(\theta_A)/F(\theta_B)]^2$$

where, F is a patter factor of antenna i.e.,

$$F = \frac{\cos\theta(2\pi\sin\theta)}{\cos\theta}.\frac{\sin\theta(2\pi\sin\theta)}{\sin\frac{\pi}{2}\sin\theta}.\sin\frac{\pi}{2}\cos(\theta)$$

is pattern factor of antenna, $\theta_A$, $\theta_B$ are the angles from the axes of the antenna main lobes to the lines A'C and B'C:

$$\phi_A = \tan^{-1}(h_t/AC) = \phi_B = \tan^{-1}(h_t/BC)$$
$$A'C = AC/\cos\phi_A,\ B'C = BC/\cos\phi_B$$

Consider 2 cases shown in Fig. 6 of tilting the antenna before and Comparison of C/I ratio before and after tilting the antenna:

$$\begin{array}{ll}
\theta_A\ \phi_A,\ \theta_B\ \phi_B, & \theta_A\ \alpha-\phi_A, \theta_B\ \alpha-\phi_B, \\
\theta_B < \theta_A & \theta_B < \theta_A \\
F(\theta_B) > F(\theta_A) & F(\theta_B) < F(\theta_A) \\
B'C > A'C & B'C > A'C \\
[\frac{B'C}{A'C}]^4 >> 1 & [\frac{B'C}{A'C}]^4 >> 1 \\
[F(\theta_B) > F(\theta_A)]^2 << 1 & [F(\theta_B) > F(\theta_A)]^2 >> 1 \\
\frac{C}{1} << [\frac{B'C}{A'C}]^4 & \frac{C}{1} >> [\frac{B'C}{A'C}]^4 \\
\frac{C}{1} > 18dB & \frac{C}{1} \leq 18dB
\end{array}$$

**Results:** The cause of tilted base station antenna is benefited to Cochannel interference reduction. The proper adjusted antenna of base station will play a more important role in cochannel interference reduction in mobile communications.

**Conclusion:** We have analyzed 5 types of co channel interference reduction methods for GSM In optimum distribution of transmitter powers, applied the complex algorithm and used regular and irregular model of the cellular system for simulation and assessed the algorithm efficiency.

In lowering the antenna height, by half than the original, the efficiency is very much improved than with normal antenna height.

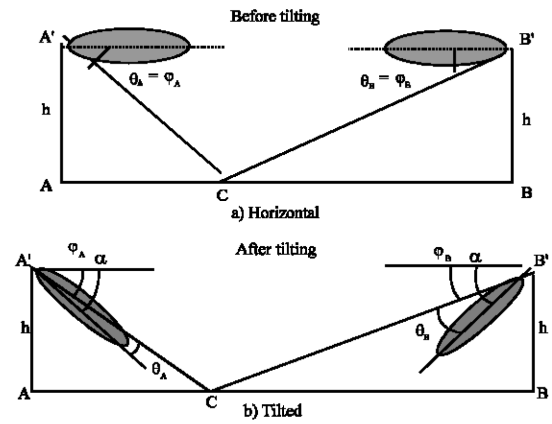


Fig. 6: (a) antenna on a high hill (b)in a valley

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