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Layout Design of CDMA Cellular Communication System to Control Spill Over of Transmitting Power in Border Areas

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ABSTRACT : Cellular communication system provides high mobility, quick connectivity, easier to carry being light weight in comparison to bulky UHF(Ultra High Frequency), VHF(Very High Frequency) and HF (High Frequency) Radio communication systems being used in the Defence forces deployed all along the border. CDMA based cellular communication system has inherent security. Hence, it is preferred over GSM system by the Defence forces. It has smaller size, light weight and longer battery life. These factors increase mobility of land forces in different kind of terrains right from mountainous, hilly, high altitude and plains. Spill over of Transmitted Power signal across the border is a serious issue. It needs serious analysis and control. The International Border/Line of Control do not have symmetrical alignment. Hence, the layout design of the communication system becomes more important. In this paper the Ladder type of communication system design with directional sectorised antenna has been evolved. This reduces the problem of spill over of transmitted power to the other side of the International border.

Keywords : CDMA, Cellular Communication, Spill over transmitted power, Ladder type design, CAF.

I. INTRODUCTION

Round the clock communication system is a vital requirement between Commanders in Headquarters and forces deployed in the field. Wireless communication systems though have less security being radiated system in comparison to wire line system which is non-radiating. However, because of ease of maintenance and inherent security Cellular communication system based on CDMA technology is preferred over GSM by the Defence forces. Typical system design layout parameters for a cellular system for optimum efficiency are Coverage area, cell size, capacity, number of subscribers it can support and QoS (quality of service).

II. DIRECT SEQUENCE CDMA SYSTEM

Direct Sequence (DS) Spread Spectrum for Code Division Multiple Access (CDMA) cellular communication limited communication system. Since CDMA is interference limited system it necessitates the requirements of rigid power control both at Mobile Handset (MH) and the Base Transceiver Station (BTS) [1].

On the reverse link, It is desired that the signal from the entire Mobile stations (MS) reaching the BTS should be preferably of equal power level so that the possibility of near far problem is reduced. The power control on the forward link depends mainly on the total power associated with the Cell at the BTS. The distribution of power to each traffic channel besides the control channels (Pilot, Synch and paging) is the deciding factor as far as cell size and coverage area is concerned [2].

Frame Error Rate (FER) is the measure of power at the MS. The FER is maintained to a pre set point value. In the reverse Link it is the Eb/It ratio at the BTS, which is required to be maintained. For a layout design of cells in the cellular communication system network, the hexagonal shape cell size is preferred being easier to optimize soft hand over and optimum cell coverage area with minimum interference.

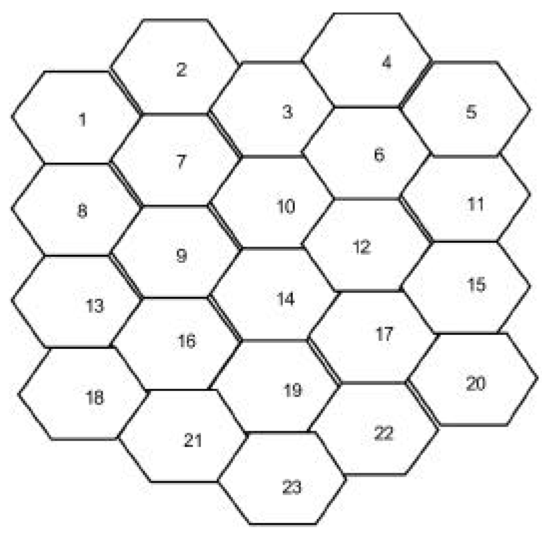

Fig 1 Cellular network with hexagonal shape cells

III. POWER CONTROL

To attain optimum capacity and performance reverse link power control is more important than the forward link power control because signal at the cell site are received from many mobile stations and if they are with varying power level the result will be the near far problem. In the open loop power control for an allowed dynamic range of 80 dB the mobile transmit the first access probe at a mean power level (Tx) [3]:

$$Tx = -Rx - K + (NP - 16 \times NPE) + IP \qquad \text{... (1)}$$

Where value of K is 73 for Band class 0 and 76 for Band class 1, NP is nominal power Rx is received power, NPE is nominal power for extended handoff *and IP* is initial power

After transmitting every probe the mobile waits for an acknowledgement and on getting the acknowledgement the mobile proceeds with the registration and channel assignment procedure. Additional power adjustment to compensate for losses due to fading is handled by the close loop power control consisting of inner loop and outer loop. The mobile mean power output with both the OLPC and ILPC will be [4]

$Tx = -Rx - K + (NP - 16 \times NPE) + IP +$ Sum of access probe correction + Sum of closed loop power control corrections. ... (2)

Fig. 2. Tx/Rx Power at BTS.

In the forward link the Pilot is transmitted with a power level of 4 to 6 dB higher then traffic channel power. Power associated with each traffic channel will be set to optimum required to maintain the desired Frame Error Rate (FER) at the mobile [5]. The mobile continuously measures the forward traffic channel FER and reports the measurements to the Base Station (PMRM), basis on the BTS takes appropriate action to increase or decrease the transmitted power on the measured logical traffic channel. The transmitting power of BTS is 42 dBs. Taking into account the existing path losses area illuminated is 12 Km. The transmitted power of BTS and received power from Mobile handset is shown in Fig 2. Thereby the power control is executed.

IV. CELL SIZE

Cell size is of main concern and depends on the receiver sensitivity. CDMA being the interference limited system the cell size on the reverse link is dictated by the Signal to interference ration (SIR), Number of users in the cell/sector (M) and the maximum mobile transmit power (Tx) [6]. On the forward link maximum cell size will be determined by the received pilot power (Ec/It) by the mobile station. This should be above a predefined threshold. However, the interference from other cell users will also affects the cell size. At the BTS for reverse link cell size the SIR per antenna is given by :

$$SIR(r) = \frac{P_m L_p(r) G"bG"m}{[NoBw]cell + [M/r - 1](vfP_m) L_p(r) G"bG"m} \quad \text{... (3)}$$

Where P_m is mobiles power amplifier output, $G"b$ and $G"m$ is the antenna gain for base station and mobile, $L_p(r)$ is the reverse path loss, fr is the frequency reuse factor.

For the forward link cell size the power associated with the Pilot is given by (Ec/It) [7] :

$$Ec/It = \frac{Q_p P_c L_p(r) G"bG"m}{[NoBw]mob + Ioc(r)Bw + Io(r)Bw} \qquad \text{... (4)}$$

Where Q_p is power associated with pilot and P_c is cell output power. Once the power control mechanism is executed as discussed above the power distance relationship at MH and BTS will be as per Fig 2.

V. LADDER TYPE LAYOUT DESIGN

To have coverage over wider area the BTS must transmit with maximum power. A Ladder type cell layout is shown in Fig 3. The cells (with blue color boundary lines) along the International Border (IB) are used with three sectorised directional antenna covering 120 degree each and remaining cells in the network are working with Omni directional antenna.

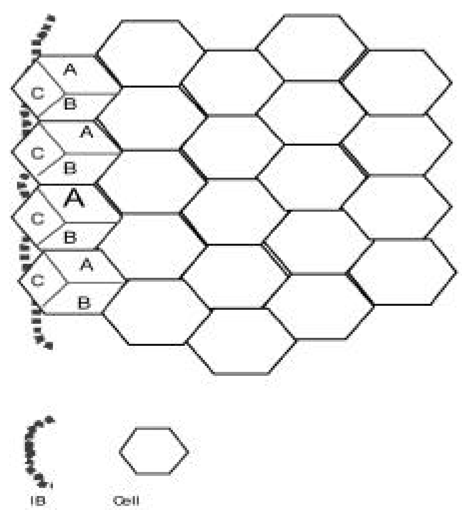

Fig 3 Ladder type layout design

The cell along the IB is arranged in the ladder shape and hence the name Ladder type layout. The BTS will transmit equal power in each sector. From the given diagram in Fig 3 we need to illuminate less distance for sector C which is facing the IB. However, in sector A and B which are covering own side we want to have maximum coverage area. Without altering the design parameters of complete

BTS the radiated power of antenna of sector C can be reduced in both trans and receive path by introduction of Controlled Attenuation Filter (CAF). This needs to be executed for sector C of all the cells facing the IB. This will introduce required additional loss in dBs for the sector C transmitted/received power. This will not have any effect on the soft hand off and other QoS of the cellular network. The effect of CAF for one cell is shown in the diagram in Fig 4. However, it is to be implemented for all the cells along the border as shown in the diagram at Fig 3.

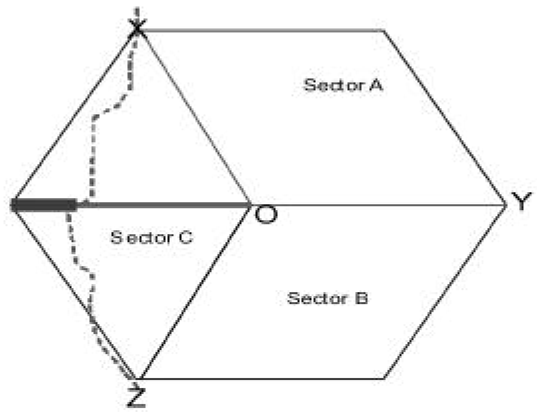

Fig 4. Use of CAF for the cell along IB

The assumed IB is along the line joining points *XZ*. The colour code Green indicates safe zone. Red colour indicates the other side of border where the signal strength of transmitted power should be far below threshold level. After inserting CAF in Sector *C* the reverse link SIR at the amplifier of the BTS will be SIR (m) and the radiated transmitted power Q_p (*m*).

$$\text{SIR}\ (m) = \text{SIR} - A(\text{dBs}) \qquad \text{... (5)}$$

$$Q_p\ (m) = Q_p - A(\text{ dBs}) \qquad \text{... (6)}$$

Where, *A* is the value of additional loss caused by CAF in dBs. The value of *A* will depend on the coverage area between the Cell site and the IB and will be distinct for each cell. Relation between CAF, Transmitted power by BTS, Received power at BTS and Coverage area (distance) has been shown in Fig 5.

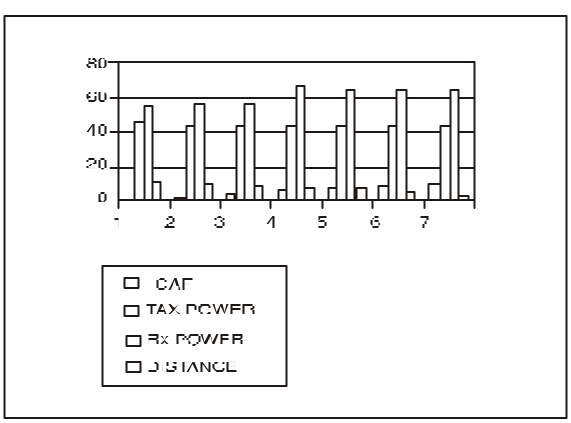

Fig 5. Tx/Rx power with use of CAF.

VI. CONCLUSION

In this paper we have tried to focus on the Ladder type layout design of cellular communication system to be used by defense forces in the border areas and also to control the spill over of transmitted power across the International border. The ladder type layout design with sectorised directional antenna and CAF has been used. The problem of spill over has been minimized for optimum use of communication system in border areas. This effect has been achieved without making hardware and software design change in the cellular equipment. This has saved the cost of seeking permission from the manufacturer and licensing authority. The presented Ladder type of design layout is found more applicable to the cells which are being sighted near border areas. The inner cells continue to work with omni directional antenna.

With the directional sectorised antenna the output power has been increased by 13 dB. This increases the coverage area in own side by 20%. In the ladder type layout design with the use of CAF has reduces the spill over power by 80%.

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