A Cell Pattern Decision for Improvement Ec/Io in CDMA Mobile Communication

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Abstract : By improving Ec/Io of pilot channel in CDMA mobile communication, the transmitting quality of mobile phone may be improved, channel capacity may be increased, and further investment and operation cost may be reduced to build a network. In this paper suggested new cell pattern decision method for base station as one of ways to improve Ec/Io of pilot channel and verified its utility through simulation and field application data.

1. Introduction

Technical development has been continued to promote transmitting quality and service of CDMA mobile communication. One of such efforts is technical development of Ec/Io(Energy Chip/Interference Others) of pilot channel.

By improving Ec/Io, the transmitting quality and service of mobile communication may be promoted and channel capacity may be increased with frequency reusable efficiency. Further, network building and operation cost may be reduced.

Main beams of all antennas of base stations, using the existent 3-SDC(3-Sector Division Cell), have been built for AMPS(Advanced Mobile Phone Service) and have been adjusted to the same direction. This is the method which can minimize signal interference between sectors or adjacent base stations, only if three sectors of service base station and frequency spectrum used in adjacent base station are different.

But when user frequency spectrum of each sector and adjacent base stations are all the same, like CDMA mobile communication, main beams of service base stations and adjacent base stations are overlapped in the boundary area of cell. It results in decreased Ec/Io of pilot channel and reduced speech quality and channel capacity.

To improve Ec/Io of pilot channel in CDMA mobile communication service, in this paper suggested new cell pattern decision method to minimize interference from adjacent base stations and verified its utility through simulation and field application data.

2. Cell pattern decision for CDMA mobile phone service

2.1 Radiation pattern of base station antenna for the suggested cell pattern decision

Most mobile phone service adopts 3-SDC to minimize mutual interference between base stations and to expand channel capacity. This method divides mobile phone service space of 360° into three areas, with each 120° and main beams of all base stations are adjusted to the same direction. The existent 3-SDC method can minimize signal interference between sectors or adjacent base stations, when user frequency spectrum of each sector in base station and adjacent base stations are different. But when user frequency spectrum of each sector and adjacent base stations are all the same, like CDMA mobile communication, main beams of adjacent base station and service base station are overlapped in service boundary area. It brings about decreased Ec/Io of pilot channel and finally leads to bad speech quality and decreased channel capacity. In case of using the existent 3-SDC method in CDMA mobile communication, channel capacity must be three times more than before division. But in reality, it increases only by 2.5 times due to the increase in signal interference of adjacent base station.

Thus, "the suggested 3-SDC", new cell pattern decision method, was presented to make up for the existent 3-SDC method in CDMA mobile communication.

In 3-SDC mobile phone service, Fig. 1 is the radiation pattern of base station antenna for the existent 3-SDC and Fig. 2 is the radiation pattern of base station antenna for the suggested 3-SDC.

The cell determined by Fig. 1 becomes a rhombus radiation pattern(Fig. 3) and the cell determined by Fig. 2 becomes a hexagon radiation pattern(Fig. 4). In Fig. 3 and Fig. 4, it is premised that the service coverage of one base station is the same

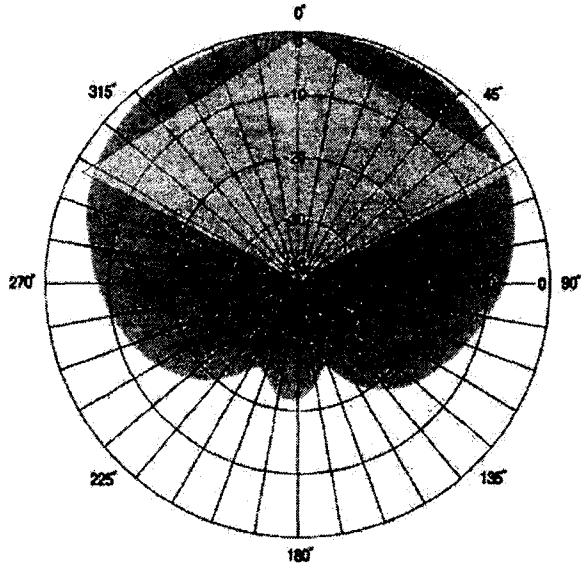

Fig. 1. Radiation pattern of antenna for the existent 3-SDC

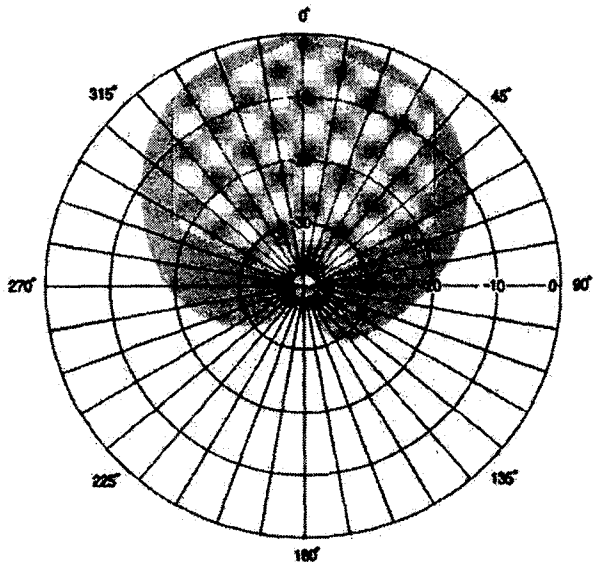

Fig. 2. Radiation pattern of antenna for the suggested 3-SDC

2.2 Suggested 3-SDC and Ec/Io

Supposing power by sector is the same and there is only pilot channel signal, six pilot signals are received at CP point of Fig. 3 and three pilot signals at CP point of Fig. 4. In 3-SDC method, Ec/Io inversely proportional to the number of overlap signal is found from equation (1).

$$\frac{Ec}{Io} = 10\log\{A_\alpha Pilot \div (A_\alpha Pilot + A_\beta Pilot + B_\beta Pilot + B_\gamma Pilot + C_\alpha Pilot + C_\gamma Pilot)\} \quad (1)$$

If the suggested 3-SDC method are used for CDMA mobile phone service, Io(interference signal by adjacent base station) at CP in Fig. 4 and channel capacity are decreased to 1/3 before cell division, on this supposition that user number and antenna power of base station are equally distributed to 1/3. It means that when subscribers are increased by three times, Io at this CP is the same as before cell area is divided into 3 sectors. In other words, Fig. 4 increases in channel capacity three times more than Fig. 3.

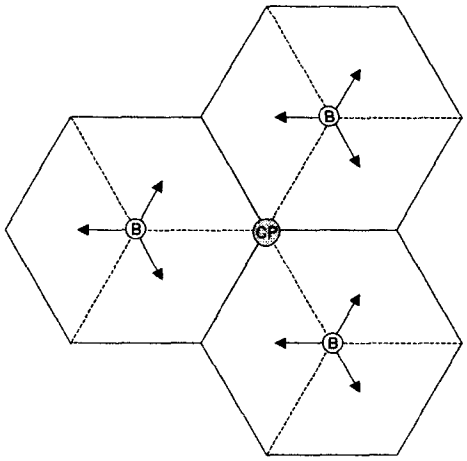

Fig. 3. Formation of the existent 3-SDC

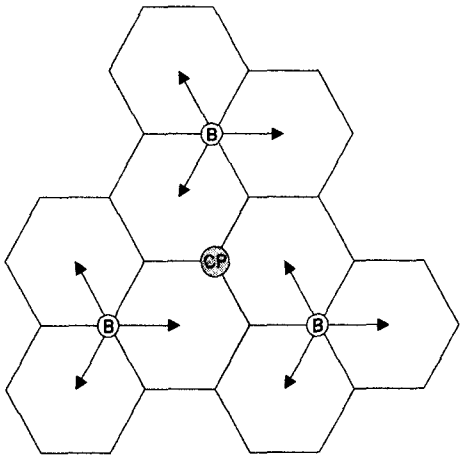

Fig. 4. Formation of the suggested 3-SDC

3. Simulation

3.1 Simulation of the existent 3-SDC and the suggested 3-SDC

For simulation, 19 base stations were arranged on the flatland at intervals of 4km and the following was assumed: base station power ; 39dBm(7.94 W), overhead channel power : 32dBm(1.58 W), and traffic unit : 10 Erl per sector. Using HATTA-OKUMURA prediction model, the existent and suggested 3-SDC were simulated (equipment used: Cell PLAN).

3.1.1 Comparison of cell area

As a result of simulation of the existent and the suggested 3-SDC, the cell area is shown in Fig. 5 and Fig. 6.

Fig. 5. Cell area of the existent 3-SDC

Fig. 6. Cell area of the suggested 3-SDC

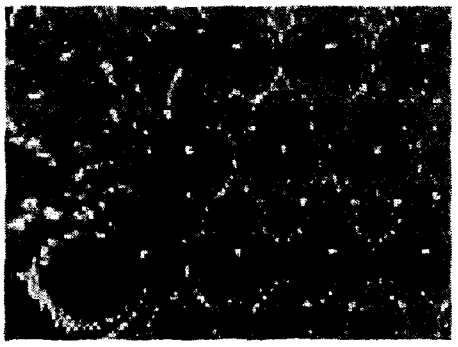

Fig. 9. Eb/Nt of the existent 3-SDC

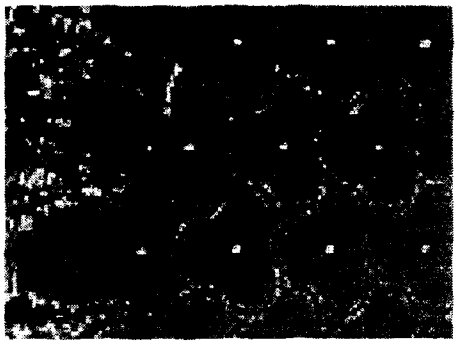

Fig. 10. Eb/Nt of the suggested 3-SDC

3.1.2 Comparison of Ec/Io

As a result of simulation of the existent and the suggested 3-SDC, Ec/Io is shown in Fig. 7 and Fig. 8.

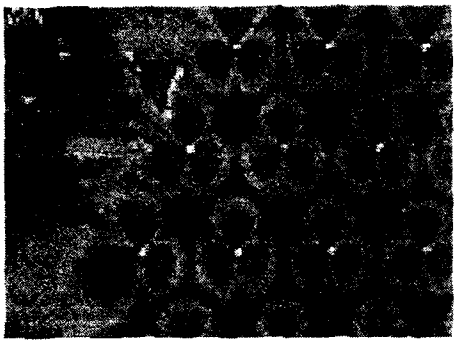

Fig. 7. Ec/Io of the existent 3-SDC

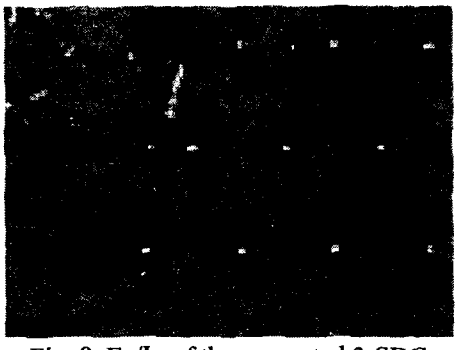

Fig. 8. Ec/Io of the suggested 3-SDC

3.1.3 Comparison of Eb/Nt

As a result of simulation of the existent and the suggested 3-SDC, Eb/Nt(Bit energy/Total noise) is shown in Fig. 9 and Fig. 10.

3.2 Analysis of the results of the existent and the suggested 3-SDC simulation

3.2.1 Results of cell area simulation

To improve Ec/Io of CDMA mobile communication, as predicted in suggestion of 3-SDC, the results are as follows.

The existent 3-SDC cell area formed hexagon cell area by three rhombus shapes. It was identified that at the worst, maximum 6 interference signals were overlapped in the boundary area of each sector from adjacent base stations. On the other hand, the suggested 3-SDC cell area formed hexagon cell area and signal overlap was decreased to less than 3 in the boundary area of each sector.

3.2.2 Results of Ec/Io and Eb/Nt simulation

Major results of simulating Ec/Io and Eb/Nt, using HATTA-OKUMURA propagation prediction model, are shown in table 1 and table 2.

Table 1. Comparison of Ec/Io distribution

Cell pattern / Ec/Io	suggested 3-SDC [%]	existent 3-SDC [%]	Distribution difference of total [%]
-40dB over	41.71	25.96	15.75
-60dB over	37.62	40.1	13.27
-80dB over	19.93	25.89	7.31
-100dB over	0.74	7.05	1
-100dB below	0	1	-1

Table 2. Comparison of Eb/Nt distribution

Cell pattern / Ec/Io	suggested 3-SDC [%]	existent 3-SDC [%]	Distribution difference of total [%]
11dB over	52.54	38.07	14.47
9dB over	16.65	17.04	14.08
7dB over	17.05	20.81	10.32
5dB over	13.76	24.08	0
5dB below	0	0	0

Based on Rx=>-94dBm Ec/Io=-8dB, and Eb/Nt=7dB, which indicate coverage determination and transmitting quality in CDMA mobile communication, simulation results were analyzed.

Table 1 shows that for the sector area where mobile phone service is possible with Ec/Io=>-8dB, the suggested 3-SDC was 99.26% and the existent 3-SDC was 92.95%. It suggests that based on the sector area for a good service, the suggested 3-SDC was expanded by 7.31%, compared to the existent 3-SDC.

Table 2 shows that for the sector area where mobile phone service is possible with Eb/Nt=>7dB, the suggested 3-SDC was 82.95% and the existent 3-SDC was 79.19%. It suggests that based on the sector area for a good service, the suggested 3-SDC was expanded by 3.67%, compared to the existent 3-SDC.

4. Conclusion

The existent 3-SDC has been used to increase the transmitting quality and frequence efficiency of AMPS mobile communication. If the existent 3-SDC is used for DCMA mobile communication, Ec/Io of pilot channel is increased due to signal interference from service sector and adjacent base stations and thus leads to decreased transmitting quality and channel capacity.

Accordingly, in this paper suggested and simulated new 3-SDC method which solves the problem of the existent 3-SDC and compared these 3-SDC methods. Finally in this paper obtained the following results.

- For the sector area where mobile phone service is possible well with Ec/Io= >-8dB, the suggested 3-SDC was 99.26% and the existent 3-SDC was 92.95%. It suggests that the suggested 3-SDC was expanded by 7.31% in service area, compared to the existent 3-SDC.
- For the sector area where mobile phone service is possible well with Eb/Nt= >7dB, the suggested 3-SDC was 82.95% and the existent 3-SDC was 79.19%. It suggests that the suggested 3-SDC was expanded by 3.67% in service area, compared to the existent 3-SDC.

The suggested 3-SDC method may be used as the mean which can improve transmitting quality, increase channel capacity, and build economical network in IMT-2000, third generation CDMA system, which is plance.

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