Frequency Coordination Between Adjacent Carriers of Two CDMA Operators

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Abstract - **Frequency coordination is the process that assigns frequency bands to neighboring or coexisting systems to minimize interference. This interference is caused by unwanted signals from adjacent frequency bands. Especially, interference is maximized by the spatial near-far problem which occurs in case two different cellular systems serve. This critical case happens when different cellular operators using the adjacent carriers do not collocate their base stations(BS). In this paper, we investigate the frequency coordination when two CDMA operators using adjacent CDMA carriers don't collocate their BS. In order to lessen the unwanted interference we put the guard band which separates adjacent carriers. This paper presents the simulation and laboratory test results to analyze the guard bandwidth requirement. For guard band simulation, we derive theoretical interference prediction models which calculate the quantity of unwanted interference. Additionally, this paper confirms the accuracy of the theoretical models with a series of laboratory test. The results in this paper assert the necessity for the guard band and discover the relation between the amount of that and the service quality.**

I. Introduction

In case that two operators make a cellular service using adjacent carriers, mutual interference has been found unless frequency separation of adjacent carriers was enough. Early paper was presented to attenuate the interference such as the interference between CDMA and AMPS system[1]. One of the solutions to lessen that was the guard band that separates adjacent carriers. The guard band is the minimum separation of carriers in order that unwanted carrier should not interfere with the wanted carrier.

In this paper, we consider the guard band when two CDMA operators make a service with adjacent carriers. In that case, CDMA customers typically subscribe to one carrier (server), but are not supported by the alternate carrier (competitor). Also we assume that base stations of two operators are not collocated. If the base stations are not collocated then the spatial near-far

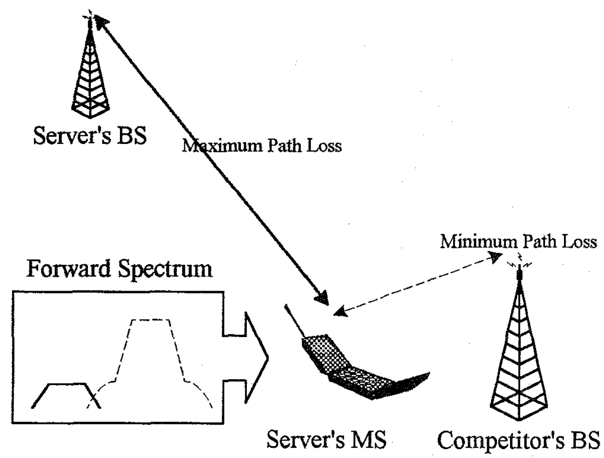

Fig. 1. Spatial near-far problem

problem occurs. Because of that problem, the difference between server's and competitor's received signal strengths can become 1,000,000 times. Then, in order to endure competitor's interference, the CDMA receivers of BS and MS reject that interference by receiver's filter. But, there is a limitation that CDMA receivers cannot endure the interference level. After the IF rejection is conducted, remainders which cannot be rejected by IF rejection become interference. Finally, we have to remove the remaining interference with the guard band.

Section II presents characteristics of CDMA transmitter and receiver. Because the rejection performance of transmit masks determines the amount of spurious interference, it plays a key role in the guard band calculation.

Section III derives the interference prediction model that access the amount of interference between adjacent CDMA carriers of different operators.

Section IV describes the result of simulation and laboratory test showing the relation between the amount of guard band and service quality such as frame error rate, pilot E_c/I_0 .

Finally, we conclude the necessity for the sufficient guard with above simulation and test result in section V.

II. The characteristics of CDMA transmitter and receiver

By considering the mask characteristics for both the transmitter and the receiver, we can obtain the estimate of the amount of mutual interference between two CDMA systems.

A. CDMA Transmitter

For the CDMA system defined in the TIA/EIA/IS-95, the transmit spectrum is initially determined by the FIR filters at the baseband. These FIR filters satisfy the spurious conditions in IS-97 and IS-98[2]. Fig 2. and Fig 3. illustrate the masks of a measured performance of typical mobile power amplifier and cell transmitter.

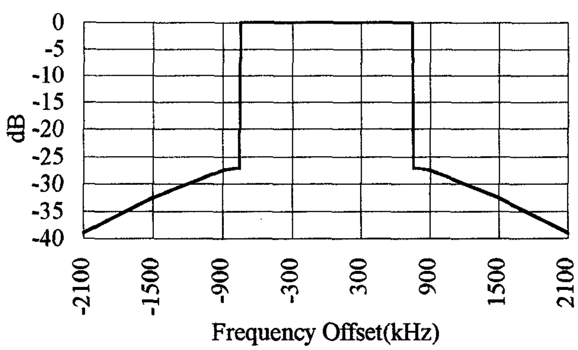

Fig. 2. Mobile Transmit Mask

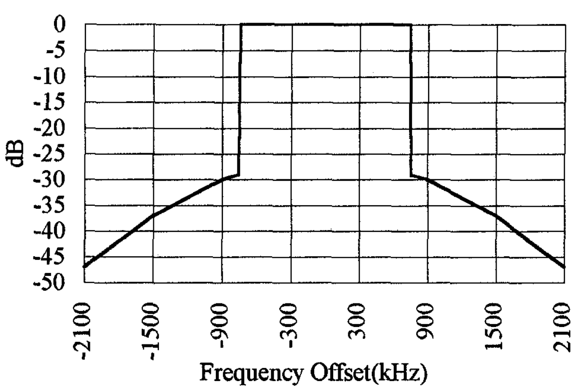

Fig. 3. Cell Transmit Mask

B. CDMA Receiver

In defining a mask for a receiver, we have to consider two points: the selectivity and the dynamic range. In view of selectivity, receiver's mask plays a key role that reject the out-band interference. In the other view, the performance of the mask depends on the dynamic range. If the dynamic range is too narrow to tolerate the interference, the performance is degraded by intermodulation product. Subsequently, loss of service(No Service indication) results when intermodulation products fall onto the in-band. But in this investigation, we assume that dynamic range of receiver is wide enough to tolerate the out-band interference. Then we do not consider the dynamic range but deliberate the selectivity to solve this guard band problem.

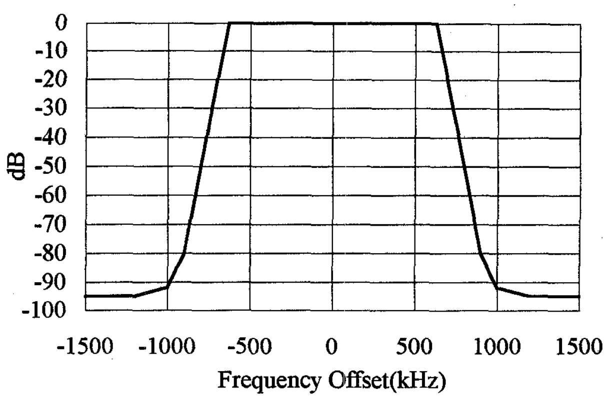

Fig. 4. Cell Receiver Selectivity

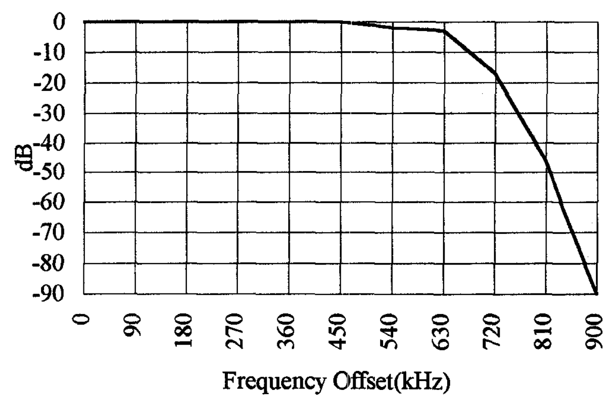

Fig. 5. Mobile Receiver Selectivity

III. Mutual Interference Between CDMA MS and BS

This investigation separates the mutual interference into two category; The first is forward link interference which is caused by the adjacent carrier that competitor's BS transmits and the second is the reverse link interference by adjacent carriers that competitor's MSs transmit.

A. Forward link interference by competitor's CDMA BS

In the spatial near-far problem, if a server's MS is more closer to a competitor's BS than a server's BS, the server MS simultaneously receives the competitor's BS signal whose strength is 60dB higher than the server's BS signal strength. This 60dB value is derived from some assumptions: minimum path loss is 70dB, and maximum path loss is 130dB, which are based on the Korea cellular environment.

From the above assumptions, we derives the following interference prediction model(1) which calculates the remaining interference that causes a bad effect on the server's MS.

$$I_{FWD}(\Delta f) = P_{BS}^{C} + L_p + R_{BS\_TX}^{C}(\Delta f) + R_{MS\_RX}^{S}(\Delta f) \quad (1)$$

P_{BS}^{C} : ERP of competitor's BS

L_p : path loss from competitor's BS to server's MS

$R_{BS\_TX}^{C}(\Delta f)$: competitor's BS transmit filter rejection loss as function of frequency offset Δf KHz from center frequency(see Fig. 3)

$R_{MS\_RX}^{S}(\Delta f)$: server's MS receiver filter rejection loss as function of frequency offset Δf KHz from center frequency (see Fig. 5)

B. Reverse link interference by competitor's CDMA MS

Reverse link interference prediction model is derived by the same method in the above section. But a contrary assumption is used in the section; if a competitor's MS is more closer to a server's BS than a competitor's BS, the server's BS simultaneously receives a competitor's MS signal whose strength is 60dB higher than the strength of the server's MS.

$$I_{REV}(\Delta f) = P_{MS}^{C} + L_p + R_{MS\_TX}^{C}(\Delta f) + R_{BS\_RX}^{S}(\Delta f) \quad (2)$$

P_{MS}^{C} : ERP of competitor's MS

L_p : path loss from competitor's MS to server's BS

$R_{MS\_TX}^{C}(\Delta f)$: competitor's MS transmit filter rejection loss as function of frequency offset Δf KHz from center frequency (see Fig. 2)

$R_{BS\_RX}^{S}(\Delta f)$: server's BS receiver filter rejection loss as function of frequency offset Δf KHz from center frequency (see Fig. 4)

IV. Simulation and Experiment

The above interference models predict the amount of interference which is produced by the adjacent carrier of competitor. The next procedure is to calculate the amount of guard band, which prevents the degradation of CDMA MS and BS, with a measure; forward link pilot E_c/I_o, and FER(frame error rate). In this paper we just had a simulation in the forward link, and verified the simulation result with the laboratory test.

A. Simulation of degradation in forward link

Before calculating the $E_c/I_o(\Delta f)$, we take the following assumptions; the transmit ERP of MS and BS are 35dBm/1.23MHz and 50dBm/1.23MHz respectively, and pilot ERP is 44.3dBm/1.23MHz. The filter characteristics of MS and BS are based on the description in section II. The path loss described in section III is based on the Korean cellular environment, especially Seoul, capital city of Korea, and the number of users in one cell is 17.

In the simulation, we calculate the $E_c/I_o(\Delta f)$ as function of the frequency offset with equation (3).

$$E_c/I_o(\Delta f) = E_c/(I_o + I_{FWD}(\Delta f)) \quad (3)$$

In the equation (3), the other parameters such as E_c, I_o except $I_{FWD}(\Delta f)$ are calculated with a link budget.

Fig. 6. depicts equation (3), displaying a simulated $E_c/I_o(\Delta f)$ as the function of Δf. There are three kinds of results that the server's and the competitor's received signal strength are -80dBm and -20dBm, -80 and -30, -80 and -40 respectively.

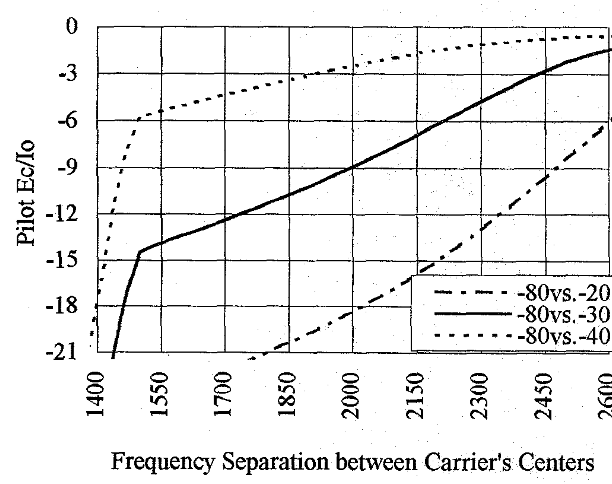

Fig. 6. Simulation Result (in forward link)

B. Experiment of degradation in forward link

Laboratory test measurements were performed to confirm the accuracy of the above simulated result. Class I mobile cellular phone(CD-3000) was used in the test. Fig. 7. is block diagram of the test configuration. The test simultaneously injects both server and competitor's signals into the cellular phone with two CDMA base stations. Two variable attanuators are used to simulate the path loss between mobile station and base station, so that the mobile station receives server's signal at -80dBm/1.23MHz and competitor's signal at -20dBm/1.23MHz, -30dBm/1.23Mhz, -40dBm/1.23Mhz respectively. Each cell has 17-simulated users and the portion of the pilot's power in the total power is set up equally to the condition of the simulation.

Fig. 8. displays the test result that shows the forward link pilot E_c/I_o as function of frequency separation between the centers of two carriers. The pilot E_c/I_o below -20dB in Fig. 8 means the loss of pilot. These curves in Fig. 8 testify the simulation result in Fig. 6, which insists the necessity for the guard band. We can see that the amount of guard band in the test result is larger than that in the simulation result because some kinds of degradation are caused by other influences such as intermodulation products generated within the cellular mobile phone receiver.

V. Conclusion

This paper suggests the guard band which separates the adjacent carriers used by different operators when the spatial near-far problem occurs. That problem makes the cases that unwanted signal becomes 40dB higher than wanted signal as well as 50dB, and 60dB.

In the simulation and laboratory test mobile station suffers call-drop, and the loss of service in the case of spatial near-far problem without sufficient guard band. These results assert the necessity for the guard band. Furthermore, the amount of the guard band depends on the difference between the levels of received signals' strength.

Acknowledgment

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Reference

[1] Samir Soliman and Chuck Wheatley, "Frequency Coordination Between CDMA and Non-CDMA Systems," pp.79-87, Int. Topical Symposium, 1995.

[2] TIA/EIA/IS-95 Interim Standard, Mobile Station-Base Station Compatibility Standard for Dual-Mode wideband Spread Spectrum Cellular System, July 1993.

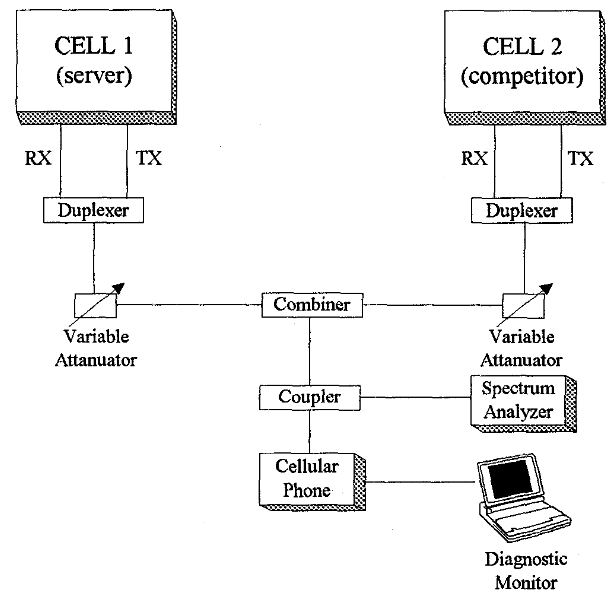

Fig. 7. Test Configuration

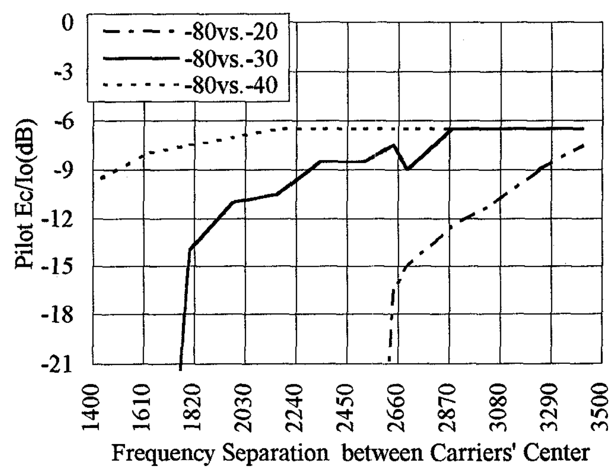

Fig. 8.Test Result (in forward link)