Method of Measuring the Occupied Bandwidth of IS-95 Base Station at Remote Site

Jong-Soo Lim · Sang-Tae Kim

Abstract

CDMA(code division multiple access) has very large peak to average power ratio(PAR) and behave as noise-like wide band digital signals with 1.2288 Mbps transmission rate. For signals with high PAR like CDMA, it is reasonable to prescribe occupied bandwidth(OBW) as average occupied bandwidth. Bandwidth measurements of CDMA signals at remote site are affected by co-channel and adjacent channel interference from adjacent CDMA base station, distortion of signal by fading effect, spurious emission and environment noises. In this study, we have compared OBW measurements in an on-air environment with those measured in a base station using adjacent channel leakage ratio(ACLR) as a reference measurement factor. As results of analysis, the OBW at ACLR≥35 dB shows nearly same statistical characteristics regardless of the measurement locations and environments.

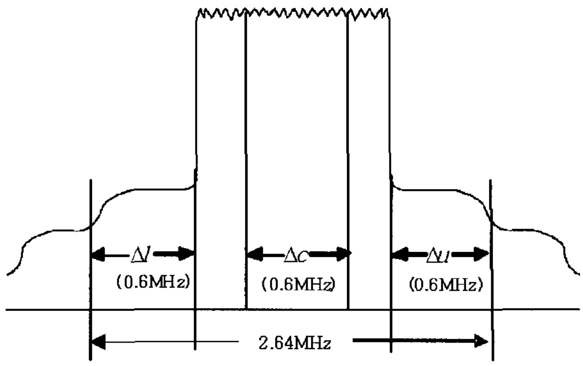
Key words : Spectrum Monitoring, Occupied Bandwidth, CDMA, ACLR.

Ⅰ. Introduction

CDMA is a multiple access scheme based on spread spectrum technology, which has been applied to digital cellular mobile communications since early 1990s[1]. The CDMA forward link consists of 64 channels, i.e., one pilot channel, one synchronization channel, 7 paging channel, and 55 traffic channels. The number of channel used depends on the number of user in the cell. Thus the output signal of the IS-95 base station has basically large peak-to-average power ratio because it consist of signals from the multiple channels, which requires linear power amplifier to transmit the signal without distortion.

In this report, method of measuring the occupied bandwidth(OBW) of IS-95 base station(BS) in the field(not directly at the transmitter) is presented. OBW measurement is a main factor for spectrum monitoring of radio equipments. We employ 0.5 % bandwidth, which has been formulated in RR147, Geneva 1994[2]. The OBW varies with time because data of each channel changes with time and ranges from 1.22 MHz to 1.3 MHz when we use a CDMA signal generator in laboratory. The measured bandwidth depends on the number of channel used and measurement duration. Thus we take the average of the measured samples to represent the statistical characteristics of the OBW.

We will describe how to measure the OBW in the field. In order to compare the measured OBW in the field with that at the transmitter, we first measure the OBW at the IS-95 transmitter. We decide the reliability of measurement by an adjacent channel leakage ratio(ACLR).



△ c :Half channel BW
△ u / △ l : Adjacent upper/lower half channel BW

Fig. 1. CDMA spectrum density for ACLR calculation.

To improve reliability, we secure a line of sight (LOS) transmission between the transmitting antenna and the receiving antenna. In order to avoid the multipath effects, we employ a directional antenna gain of 7.3 dBi. As shown in Fig. 1, we calculate ACLR"s from both the upper band and the lower band and make only use of the larger of ACLR(△ c /△ u) in

Manuscript received September 30, 2002 ; revised March 4, 2003.
Electronics and Telecommunication Research Institite, 161 Kajong-Dong, Yusong-Gu, Taejon, 305-350, Korea.

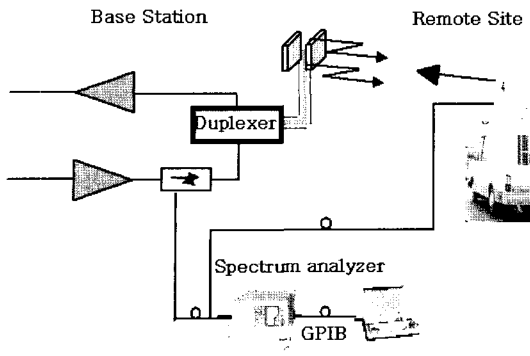


Fig. 2. Block diagram of measurement system.

the upper band and ACLR($\triangle c/\triangle u$) in the lower band.

From both analyses from the laboratory measurement and field measurement, we have some conclusions; when ACLR$\geq$35 dB, both analyses are nearly the same and their distributions have normal distribution with mean of 1,263.8 kHz and standard deviation of 14.9 kHz. Based on this statistical property, we determine an appropriate number of measurements to obtain some confidence and error.

Ⅱ. Measurement Setup and Data Analysis

2-1 Measurements Setup

A) System specification of base station and measurement environments.

Surrounding environment and system specification of base station, which complies with IS-95 air-interface, are as follows(next Table).

B) Parameter setting of spectrum analyzer

- Center Frequency(CF): 875.79 MHz
- RBW: 30 kHz

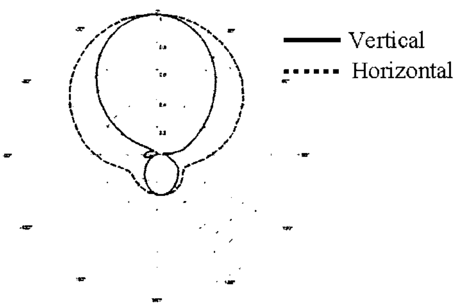


Fig. 3. Antenna pattern of remote site.

Name	Specifications	Surrounding environment
BS A	- Center frequency: 875.79 MHz - Feed line: 30 m - Antenna gain: 14 dB - Output power of Tx. AMP.: 25 w/FA	Rural area around which there is no tree or obstacle of building
BS B	- Center frequency: 875.79 MHz - Feed line: 30 m - Antenna gain: 14 dB - Output power of Tx. AMP.: 25 w/FA	Street around which buildings lower than 4 floor are found here and there
BS C	- Center frequency: 875.79 MHz - Feed line: 23 m - Antenna gain: 14 dB - Output power of Tx. AMP.: 25 w/FA	Rural area around which there is no tree or obstacle of building

- VBW : 300 kHz
- SPAN(scan bandwidth) : 2.64 MHz
- Sweep time : 20 ms
- Detection mode : Sample mode
- Number sample point in a scan bandwidth : 401 points
- Average mode : Off

C) Specification of receive antenna

- Antenna type : Log periodic dipole
- Frequency band : 400 MHz~3 GHz
- Antenna gain : 7.3 dBi (@800 MHz)
- Front-back ratio : 15 dB

2-2 Measurements Procedure

A) Direct measurement at BS

Connect to RF monitoring port to base station

Adjust signal attenuation to input range of spectrum analyzer

Collect samples(3000 measurements) per each BS

B) In the field

Search location in roadmap for each LOS measurement

Secure LOS between base station and receiving antenna (where there is no obstacle on First Freznel zone)

Align antenna to get maximum signal power

Collect samples (2000 measurements) at each location

2-3 Data Analysis

The values of power levels measured in IF band for each sample point (we used 401 points) within scan bandwidth were transferred to the control PC per every sweep. In the control PC, OBW was calculated and analyzed by statistical techniques.

Ⅲ. Measurement Results

3-1 Measurement Results on the Base Station

In BS A, for ACLR value of 45 dB~47 dB, bandwidth of 1,320 kHz to 1,207.8 kHz was measured. The average band-width of 1,263.4 kHz and standard deviation of 14.4 kHz for all the measurements of BS A was obtained by data analysis. In BS B, for ACLR value of 43 dB~44 dB, bandwidth of 1,313.4 kHz to 1,207.8 kHz was measured. The average bandwidth of 1,263.5 kHz and standard deviation of 14.2 kHz for all the measurements of BS B was obtained by data analysis. In BS C, for ACLR value of 47 dB~49 dB, bandwidth of 1,313.4 kHz to 1,214.4 kHz was measured. The average bandwidth of 1,263.4 kHz and standard deviation of 14.4 kHz for all the measurements of BS C was obtained by data analysis. It is clear in Table 1 that average OBW values for several ACLR values are almost identical. That is, average OBW is nearly constant for 49 dB≥ACLR≥43 dB. OBW distribution for each ACLR measured in BS A, B and C had almost same normal distribution characteristics[Fig. 4].

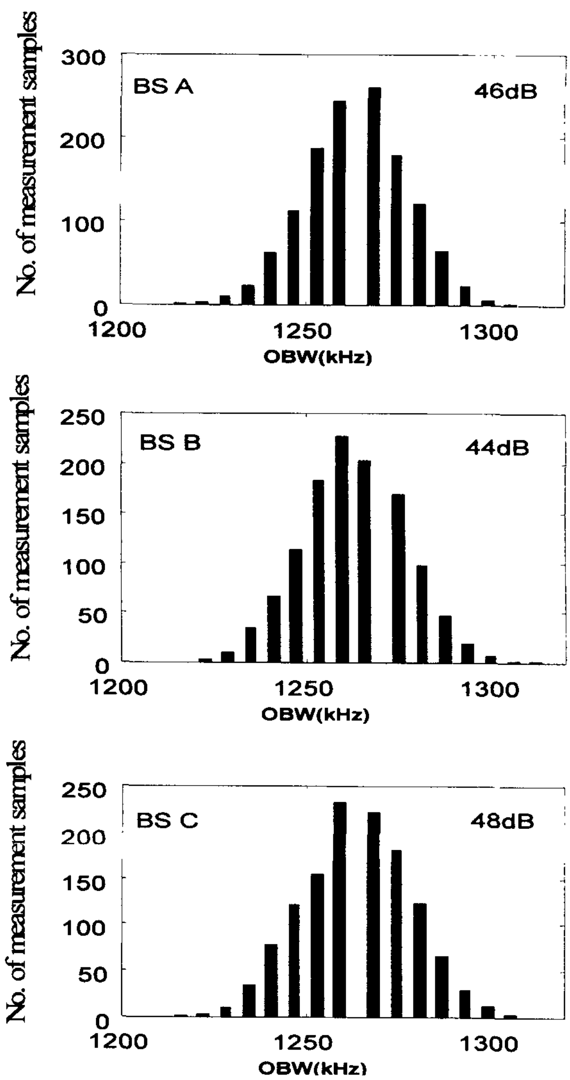


Fig. 4. OBW distribution at base station.

3-2 Measurement Results in the Field

The measurement was performed at three sites; both BS A and BS C are open area and BS B is suburban. The number of measurement point was 17 for BS A, 22 for BS B and 20 for BS C. The measured ACLR value varied from 25 dB to 42 dB for BS A[Table 1], from 16 dB to 44 dB for BS B and from 22 dB to 42 dB for BS C. The OBW for ACLR≥35 dB lies around the average OBW of 1263.4 kHz measured at BS.

In Fig. 6, the distribution of OBW was shown for ACLR of 35 dB, 37 dB, 39 dB and 41 dB.

3-3 Comparison of Direct Measurements at Base Station with Field Measurements

We compare the field measurements with direct measurements of BS for ACLR≥35 dB at each BS [see Table 2]. Differences in average OBW between direct measurement and field measurement for BS A, BS B and BS C are 1.1 kHz, 0.2 kHz and 0.3 kHz, respectively. Differences in standard deviation for BS A, BS B and BS C are 0.1 kHz, 0.7 kHz and 0.8 kHz, respectively. The obtained values from the field measurement at BS A and BS B are greater than directly measured values at base station and result of field measurement at BS A is less than that at base station. Maximum difference (1.1 kHz) is very little value in comparison with average OBW (1,263 kHz). From the above results, it is clear that statistical characteristics of base station measurement and that of field measurements were almost same for ACLR≥35 dB.

Table 1. Average OBW for each ACLR measured in on-air (BS A).

ACLR (dB)	Numbers of measurement samples:	Average OBW (kHz)	Standard deviation (kHz)	Maximum value (kHz)	Smallest value (kHz)
25	672	1284.3	13.8	1320.0	1234.2
26	938	1280.0	13.5	1326.6	1234.2
28	415	1278.9	13.5	1313.4	1234.2
29	815	1273.2	13.9	1306.8	1227.6
29	810	1275.8	13.7	1313.4	1227.6
29	669	1273.8	14.4	1313.4	1227.6
30	739	1271.9	13.9	1313.4	1234.2
30	549	1274.8	13.8	1313.4	1227.6
30	853	1271.8	14.3	1320.0	1227.6
31	352	1275.5	13.9	1306.8	1234.2
31	326	1279.0	13.7	1313.4	1240.8
32	480	1273.0	15.9	1313.4	1221.0
32	721	1275.5	14.7	1313.4	1227.6
32	850	1277.0	14.0	1320.0	1227.6
33	462	1271.5	14.8	1313.4	1234.2
33	651	1273.5	14.1	1320.0	1227.6
33	599	1274.3	13.3	1320.0	1227.6
34	398	1271.7	13.6	1300.2	1227.6
35	923	1268.2	14.5	1313.4	1221.0
36	421	1262.8	14.1	1300.2	1214.4
36	376	1268.2	14.4	1300.2	1227.6
36	559	1267.3	13.9	1313.4	1214.4
37	706	1266.3	13.9	1300.2	1221.0
37	859	1260.4	14.8	1306.8	1221.0
37	869	1268.2	14.0	1306.8	1221.0
38	673	1265.3	14.3	1313.4	1221.0
38	543	1258.4	15.0	1300.2	1207.8
38	585	1265.4	14.3	1306.8	1221.0
39	778	1266.6	14.4	1300.2	1181.4
39	646	1263.7	13.6	1300.2	1221.0
39	417	1268.1	14.8	1300.2	1227.6
40	855	1262.5	14.3	1306.8	1207.8
40	882	1263.4	14.1	1300.2	1214.4
40	900	1263.8	14.1	1306.8	1221.0
41	814	1263.5	13.6	1306.8	1214.4
41	572	1263.0	14.2	1306.8	1221.0
42	792	1261.5	14.4	1306.8	1214.4

3-4 Choice of Measurement Numbers

In the field environment, an average OBW was 1,263.8 kHz with the standard deviation of 14.9 kHz for ACLR $\geq$ 35 dB for all three base stations, and difference of average OBW at each BS from the overall average OBW was 0.7 kHz, +0.1 kHz, +0.7 kHz, respectively, and the differences of standard deviation at BS A, B and C are 0.4 kHz, 0 kHz and -0.3 kHz,

Table 2. Comparison between the directly measured OBW at BS and field measurement.

Name	Numbers of measurement samples:	Average OBW (kHz)	Standard deviation (kHz)	Maximum value (kHz)	Minimum value (kHz)
BS A	13,189/ 2,698	1264.5/ 1263.4 (1.1)	14.5/ 14.4 (0.1)	1313/ 1309	1181/ 1212
BS B	9,778/ 2,326	1263.7/ 1263.5 (0.2)	14.9/ 14.2 (0.7)	1313/ 1313	1201/ 1214
BS C	10,753/ 2,706	1263.1/ 1263.4 (0.3)	15.2/ 14.4 (0.8)	1320/ 1308	1195/ 1219
Total		1263.8/ 1263.4 (0.4)	14.9/ 14.3 (0.6)		

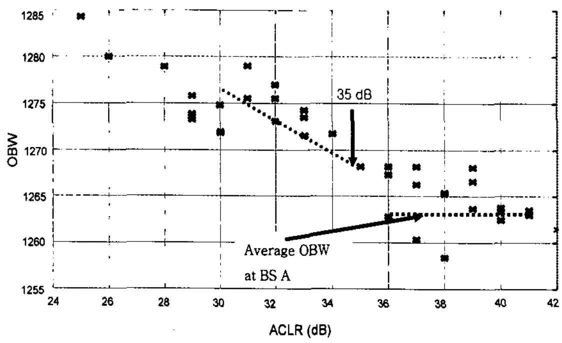


Fig. 5. Average OBW versus ACLR at BS A.

respectively. Therefore, it manifest that statistical characteristics was identical at all three BS's. In the field environment , the average OBW was 1,263.8 kHz and the standard deviation was 14.9 kHz for ACLR$\geq$ 35 dB and it had statistically normal distribution characteristics. From the these results, proper number of measurements to get 99 % confidence and ± 0.1 % error range should be near 922-points[3].

Ⅳ. Conclusions

It is very difficult to verify confidence of the measured value for the CDMA OBW through the field measurement because of co-channel interference and multi-path fading effects. However, we can get high confidence about measured OBW if we can find the measurement positions with large ACLR by using high-gain directional antenna. For verification of confidence, we have measured an OBW in various measurement environments and compared an OBW in the field with that measured in a base station.

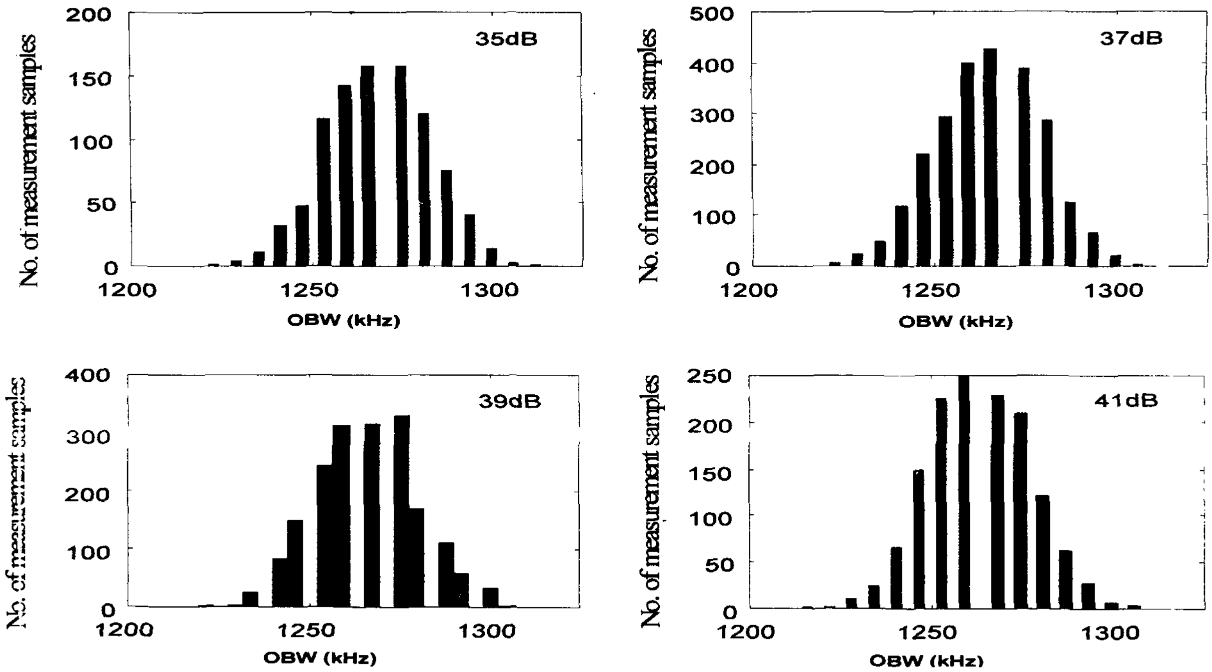


Fig. 6. Distribution of average OBW as a function of ACLR.

As a results of analysis, the OBW at ACLR≥35 dB shows nearly same statistical characteristics regardless of the measurement locations and environments and followed a normal distribution of mean = 1263.8 kHz and standard deviation = 14.9 kHz. On the basis of statistical property, we presented the appropriate number of measurements for a particular confidence and error.

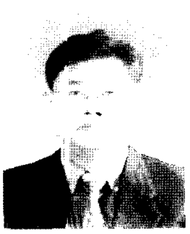
References

[1] *EIA/TIA IS-95*, Mobile station-base station compatibility standard for dual-mode wideband spread spectrum cellular system, 1993.

[2] *Radio Regulation*, Geneva, Article 1, no. 147, 1994.

[3] Ronald E. Walpole, Raymond H. Myers, *Probability and Statistics for Engineers and Scientists*, Macmillan Publishing Company, 1989.

Jong-Soo Lim



He received the B.S. and M.S. degree from Kyungbuk University in 1988 and 1990, respectively. He had been with the SK Telecom from 1995 to 1998. In 1999, he joined the Department of Radio Technology, Electronics and Telecommunications Research Institute as a research staff. His research interests are Radio monitoring and Signal Analysis.

Sang-Tae Kim

He received the B.S. and M.S. degree from the Korea Maritime University in 1993 and 1995, respectively. From 1995 to 1998, he was a researcher of SARACOM. In 1999, he joined the Department of Radio Technology, Electronics and Telecommunications Research Institute as a research staff. His research interests are RF circuit and system design, and SDR system design.