Propagation Characteristics for Radio Channel of MIMO System in Urban Area at 781 MHz

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Abstract

This paper presents the measured propagation characteristics like a path loss, delay spread and angular spread for urban environments in Jeju at 781 MHz. Measurements were made with a wide band MIMO channel sounder using a pseudo noise (PN) mode, 50 Mcps, 20 ns resolution and 40.96 μs maximum delay. Base station (BS) antenna height of 5 m was tested with a mobile station (MS) antenna height of 1.6 m to emulate a similar situation. The results presented in this paper are compared to radio channel measurement results made in New York at 910 MHz and Washington DC at 900 MHz.

Keywords: UHF, path loss, delay spread, angular spread, MIMO

1. Introduction

By the rapid increase of demand for wireless communications and the explosive increase of the mobile communication services, researches for channel characteristics of urban radio channel in the UHF band's are required [1]-[3]. Also, a rapid growth of radio services leads to the deficiency of the frequency resources and this phenomenon is clearly appearing at the UHF band's frequencies. Due to this reason, analysis of propagation characteristics in the UHF band is needed for mobile wireless communications [4]-[5]. Mobile communication systems require higher bit rates and data capacity. MIMO systems are solution for these requirements with neither increasing the transmission power nor the frequency range allocated by taking advantage of multiplicity and diversity [6]-[10].

In this work we presents results from urban MIMO measurement campaign at 781 MHz. Multipath characteristics for the 4×4 MIMO channels are extracted from the measured data. We focus on basic channel characteristics, which are important for the development and validation of realistic channel model. Specifically, we investigate the distance dependency of the path loss, delay spread, and angular spread at 781MHz bands as a candidate frequency of new services.

From the analysis, it was deduced that this method is applicable with good accuracy for urban area in the Korea. Currently, we proposed some parameters to add in the TABLE 9 of REC. ITU-R P. 1411-5 [11].

2. Measurement system and method

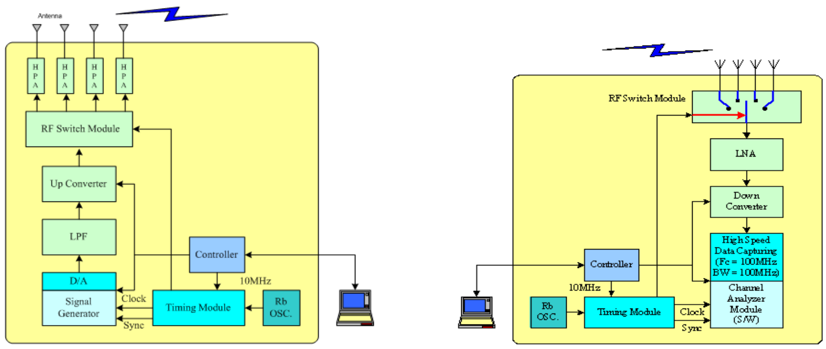

Figure 1: Measurement systems (left: Transmitter, right: Receiver)

The channel sounder is acted with pseudo noise (PN) mode, 50Mcps, 20ns resolution, and maximum delay time is 40.96μs. The transmitter in the measurement system is capable of transmitting the 10-W carrier wave at 781MHz. It was located at a base station (BS) with the antenna height (hb) of 5 m. The mobile station (MS)'s antenna with the antenna height (hm) of 5 m was set on the end of the rooftop of the motor vehicle because the reflection to the rooftop of vehicular could be ignored. Also, the half-wavelength dipole antennas with the vertical polarization were used for both the transmission and reception. Channel sounder used the high speed switching mechanism and periodic pseudo random binary signals method considering next generation mobile communication system.

Measurements are performed the urban area in the Jeju Island using antenna array mounted on two cars. Measurement systems consist of transmitter and receiver and its configuration is shown the Fig. 1. Data acquisition of measurement system is automatically stored by 2 GB with in a second.

The measurement environment shown in Table 2 and Figure 2 is urban area in the Jeju-island. They have many high-rise buildings and wide roads with heavy traffic. The measurement was performed at the 2 places of urban area in Table 2, at 200 test points of each place, and over 100 times of each test point.

Table 2: Measurement environment

Area	Location	Feature
Urban	Jeju Island	· High-rise buildings (above 20 floors) at one side of 8 lanes road (30m wide) and no building at the other side of road

Figure 2: Measurement Environment

They have many high-rise buildings and wide roads with heavy traffic. The measurement was performed at the 2 places of urban area in Table 2, at 200 test points of each place, and over 100 times of each test point.

3. Propagation characteristics

The radio wave's strength is attenuated due to the absorption by mostly oxygen and vapor when the wave propagates through the atmosphere. And, the attenuation unit of dB/km means the attenuation coefficient in atmosphere and depicts the attenuation per unit distance. In general, the attenuation coefficient on the communication applications is approximately 15dB/km.

To estimate the propagation characteristics and define appropriate wireless environment, most researchers has been studying and developed the propagation models such path loss and delay profile [10].

The propagation models are developed using the statistical method based on measurement or theoretical approach method. Especially, the theoretical scheme is very effective method rather than statistical methods, because of the analysis speed's improvement and the accuracy.

3.1 **Path loss**

The observed signal strength values are converted into path loss values using the received power, transmitted power and gains of the transmitting and receiving antennae. These are designated as observed path loss values. The path loss exponents from the observed path losses are deduced as follows.

$$PL(d) = PL_0 - n \cdot 10\log_{10}\frac{d}{d_0} + X_\sigma \qquad [\text{dB}] \qquad (1)$$

where PL_0 is the value of path loss (in dB) at the reference distance d_0, n is the distance exponent, and X_σ is a zero-mean Gaussian random variable with standard deviation σ. The random variable X accounts for the location variability or shadow fading that is generally attributed to differences in the degree to which the path is obstructed at different points throughout the coverage area. Path loss result is shown in Figure 3 with fitting result. Path loss exponent is 10.42 with the initial value -42.30.

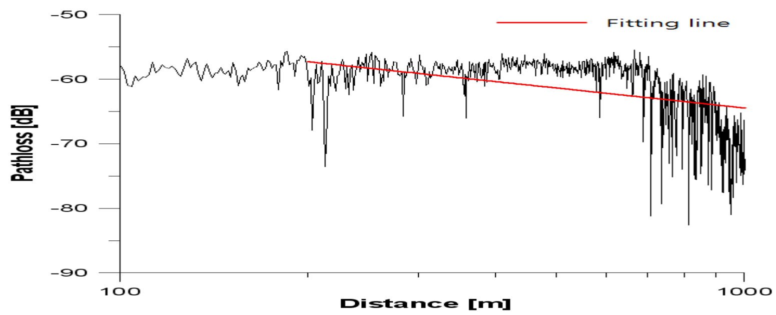

Figure 3: Path loss characteristics of UHF bands in the urban area

3.2 **Delay spread**

Delay spread is due to multipath reflections and causes to the inter symbol interference (ISI). Therefore, the maximum data rates on the communication applications could be limited by ISI. The RMS delay spread, which is defined as the square root of the second central moment of the PDP (power delay profile), was computed using a threshold level of 20 dB above the noise. The noise level was estimated from a signal free portion of the PDP by averaging the power spectral density over 2–3μs. Table 3 shows the measurement results of the mean R.M.S delay spread and their standard deviations in the urban area.

Table 3: Delay result

Area	R.M.S delay spread (ns)	Standard deviation (ns)
Jeju	1750	200

Table 3: Comparison of measurement and reference data

Region	Frequency(MHz)	Delay Spread(ns)	Measurement site
Jeju Island(Korea)	781	1750 avg.	Urban
Washington DC (USA)	900	2000 avg	Urban(worst case)
New York [4](USA)	910	1300 avg.	Urban

Above the result, our measurement data is bigger than New York and Washington DC cases. But, both result have a similar value, it is mean that our measurement result are reasonable values.

3.3 **Augular spread**

There are also angular spread that are measured in this campaign and reported in this paper. This parameter ranges between 0 and 1 and describes how multipath power concentrates about a single direction-of-arrival in space, with 0 denoting perfect concentration in one direction and 1 representing no clear directional bias in arriving multipath power. The angular spread is calculated from complex Fourier coefficients of the angle spectrum. Angular spread result is shown in Figure 5.

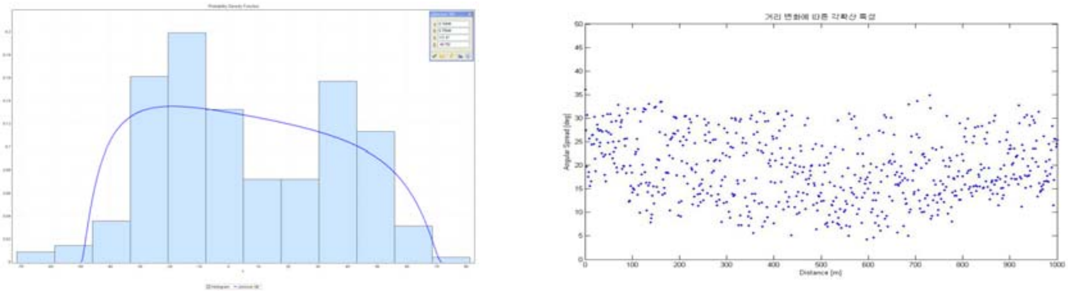

Figure 5: Angular spread (left: PDF distribution, right: versus distance)

5. Conclusion

We constructed of measurement system and measured propagation characteristics in the urban area. And, we measured the characteristics of the wave propagation at 781MHz bands as a candidate frequency of new services. Propagation characteristics for the 4×4 MIMO channels are extracted from the measured data. And, we compared with measurement data.

From the analysis, it was deduced that this method is applicable with good accuracy for urban area in the Korea. Currently, we proposed some parameters to add in the TABLE 9 of REC. ITU-R P. 1411-5.

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