

Analysis of Radio Channel Characteristics in the Outdoor Environments at the 781 MHz Frequency

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Abstract — This paper presents the measured radio propagation characteristics in outdoor environments for new mobile wireless system in the Jeju island at 781 MHz frequency. The propagation characteristics at 781MHz seem to be similar at 900MHz, but detailed characteristics can't be predicted without research for wireless communication system at the 781 MHz frequency. Also, there are few studies on process of signal transfer for the mobile communication system. In this paper, measurements were made with a wide band 4x4 MIMO channel sounder. And, we derived the radio channel characteristics (Path Loss, Delay Spread, Angular Spread and K-factor) and compared with Simulation data of same environments. Currently, delay spread and angular spread had been listed on the new release document of ITU-R Recommendation P. 1411-5.

Keywords—radio channel, outdoor, path loss, delay spread, angular spread, K-factor

I. INTRODUCTION

Recently, wireless technology is evolving rapidly and data requirements are greatly increased [1]-[3]. A rapid growth of radio services leads to the deficiency of the frequency resources in the UHF band's frequencies. And, 781 MHz frequency will be allocated new mobile communication instead of the existing DTV system's frequency band. So, a study on channel characteristics of signal transfer process is necessary. 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 present results from urban MIMO measurement campaign at 781 MHz frequency. Multipath characteristics for the 4x4 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. And, we compared the measurement and simulation data for verifying our results.

From the analysis, it was deduced that this results are applicable for radio channel in outdoor environments in the Korea. Currently, we proposed some parameters to add in the ITU-R recommendation and delay spread and angular spread had been listed on the new release document of ITU-R Recommendation P. 1411-5 [11].

II. MEASUREMENTS

Measurements were performed at the 4 places in the Jeju Island using antenna array mounted on two cars. The representative measurement environment was shown in Figure 1 and Table 1. They have many high-rise buildings and wide roads with traffic.



Figure 1. Measurement system configuration(left: Tx, right: Rx)

TABLE 1. MEASUREMENT ENVIRONMENT

Area	Location	Feature
Urban	Jeju Island	High-rise buildings (above 10 floors) and 4 lanes road (16m wide)

It was located in the middle of the rooftop of motor vehicle at a base station (BS) with the antenna height of 5 m. The mobile station (MS)'s antenna with the antenna height of 1.5 m was set on the end of the rooftop of the motor vehicle because we could be ignored the reflection since installed absorber on the rear surface.

And, we measured the radio channel characteristics with channel sounder. Figure 2 is our measurement system.

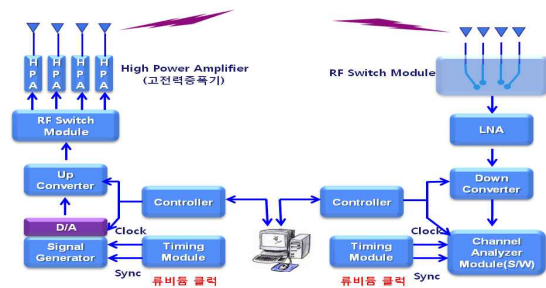


Figure 2. Measurement system configuration(left: Tx, right: Rx)

The channel sounder is acted with pseudo noise (PN) mode, 50Mbps, 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. Channel sounder used the high speed switching mechanism and periodic pseudo random binary signals method considering next generation mobile communication system. Data acquisition of measurement system is automatically stored by 2 GB with in a second. Also, the half-wavelength dipole antennas with the vertical polarization were used for both the transmission and reception.

III. RESULTS

Actually in the outdoor environments like urban, suburban and rural, radio waves are reflected, penetrated, diffracted, and barely transmitted along the complicated multipath. Especially, path loss, delay spread and angular spread during the multipath transmission affect the communication quality, transmission speed and capacity.

A. Path loss

Path loss is dependent parameter of distance and it is limiting the coverage.

$$G_d(d) = G_0 - 10n \log_{10} \left(\frac{d}{d_{ref}} \right) + X_\sigma, \quad [dB] \quad (1)$$

where G_0 is the path gain at the reference distance d_{ref} (1m), n is path loss index, and X_σ is standard deviation. Path loss result is shown in the TABLE 1 and in the Figure 3 with fitting result.

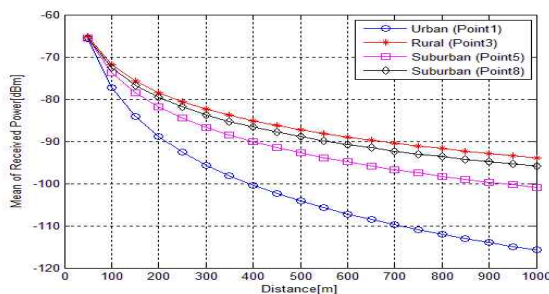
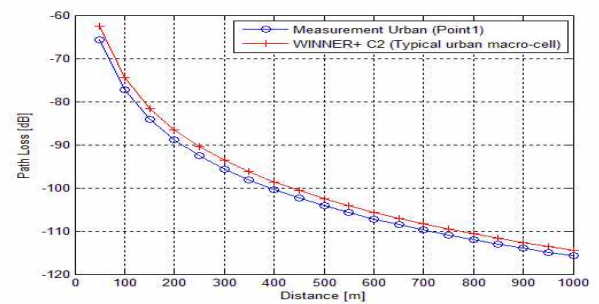


Figure 3. Received level according to the distance

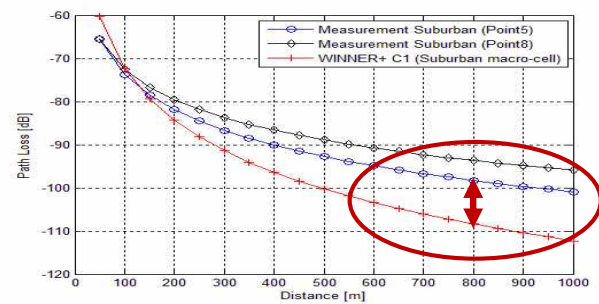
TABLE 2. MEASUREMENT ENVIRONMENT

Measurement conditions				G_d		
Area	f (GHz)	h_b (m)	h_m (m)	G_0	n	X_σ (dB)
Urban	0.781	5.0	1.5	-0.253	3.851	2.4
Suburban1				-19.25	2.723	4.3
SubUrban2				-26	2.33	3.1
Rural				-27.61	2.209	3.1

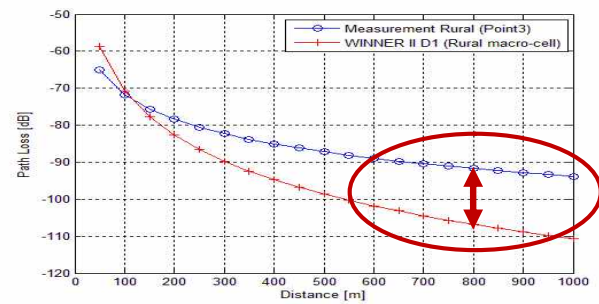
And, we compared with existing propagation model corresponding to the 781 MHz frequency, that results were shown the Figure 4.



(a) Urban



(b) Sub-urban



(c) Rural

Figure 4. PDP according to the distance

Path loss of urban case is very similar from WINNER model. But, path losses of suburban and rural case have about more 10 dB differences. From the results, we need to new path model for new mobile communication system at 781 MHz frequency to appropriately predict.

B. 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.

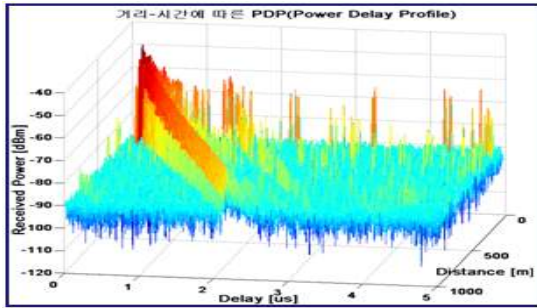
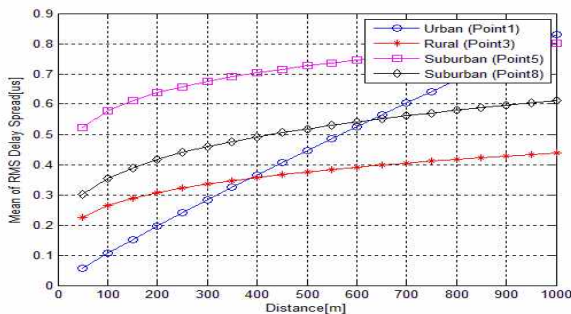
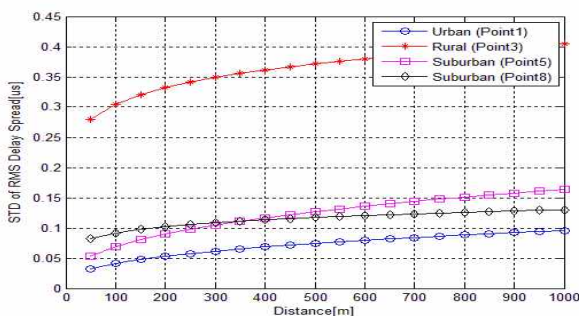


Figure 5. PDP according to the distance

Figure 5 is PDP of our measurement data. The delay spread is calculated from power delay profiles given by the square of magnitude of the channel impulse response. Delay spreads were deduced from measurement data.



(a) Mean of RMS delay spread



(b) STD of RMS delay spread

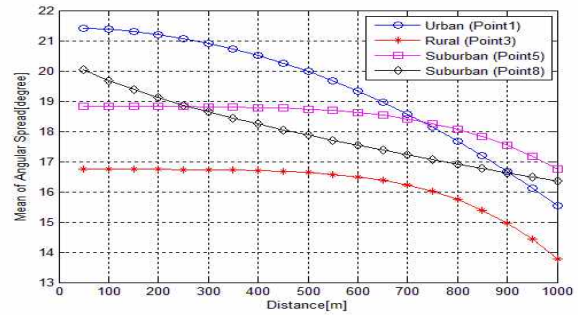
Figure 6. Delay spread according to the distance

Figure 6 was shown the Mean and standard deviation of RMS delay spread.

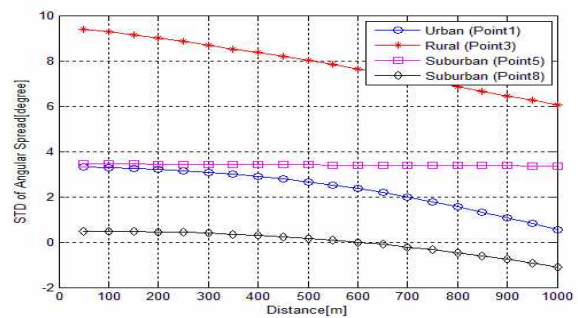
C. Angular spread

Angular spread is due to multipath of signal transferring procedures. Measurement performed at the dense urban micro-cell environment in urban area. Angular spread

coefficients are introduced based on measurements in urban areas for distances of 10~1 000 m, under the LOS cases at a frequency of 781MHz. 4 elements omnidirectional linear array with Bartlett beam-forming method is used for deriving the angular profile. The Mean and standard deviation of Angular spreads are shown in the Figure 7.



(a) Mean of RMS angular spread

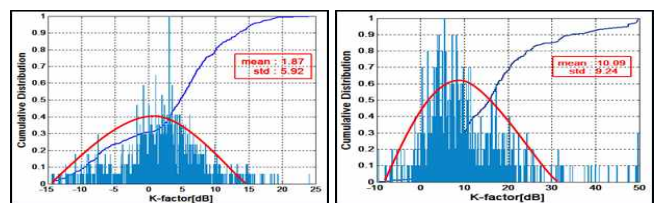


(b) STD of RMS angular spread

Figure 7. RMS angular spread versus distance

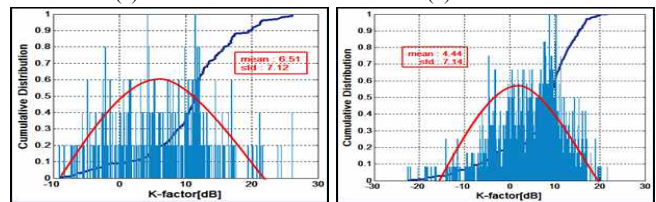
D. K-factor

K-factor is representative the statistical distribution of wireless channel. Our results are shown in the Figure 8.



(a) Urban

(b) Suburban



(a) Urban

(b) Suburban

Figure 8. K-factor versus distance

Above results were mean that outdoor environments were dominated the LOS (line for sight) case in our measurement points.

E. Verification of our measurement results

To verify the validity of measurement results, we compared with our result and reference result. We made a 3D model like a similarly real environment for ray-tracing simulation. And, we simulated radio propagation in outdoor environments and compared with simulation results. Figure 9 is shown the ray-tracing simulation configuration.

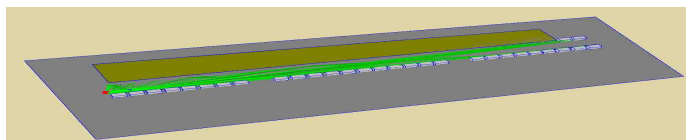
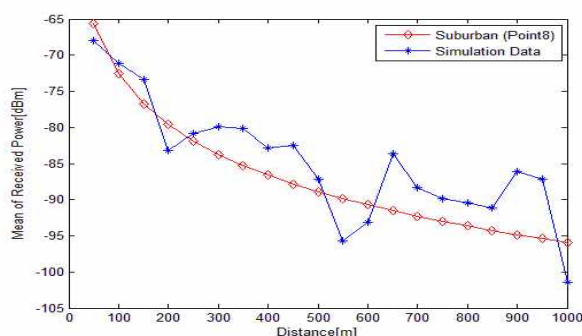
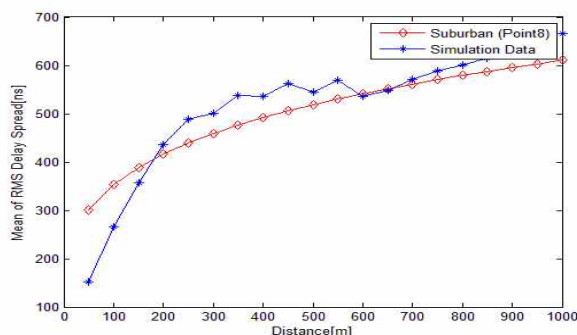


Figure 9. Ray-tracing simulation configuration



(a) Received level according to the distance



(b) Mean of RMS delay spread

Figure 10. Ray-tracing simulation configuration

Figure 10 is shown the compared data of received level and RMS delay spread. Above the result, measurement and simulation data have similar trend. So, our measurement data have reasonable values. In this result, our measurement and analysis method are appropriate at the 781 MHz frequency. Our results are validity in outdoor environments.

IV. CONCLUSION

We constructed of measurement system, and measured the characteristics of the wave propagation in the outdoor environments at 781MHz frequency as a candidate frequency of new mobile communication services. We deduced propagation characteristics like a path loss, delay spread,

angular spread and K-factor for MIMO wireless system in the outdoor environments from the measured data. And, we compared radio channel characteristics with existing channel model. From the comparison results, we had seen the difference channel characteristics. Path loss characteristics have different trend in the suburban and rural case. So, we need to make a new channel model for new mobile communication system. In the near future, we will research more channel model of correlating frequency bands, and make a new path loss model. Finally, to verify the validity of analysis results, measurement data compared to simulation results. Measured data and simulation data get a similar tendency. So, we are known that our results are appropriate data.

Currently, delay spread and angular spread had been listed on the new release document of ITU-R Recommendation P. 1411-5.

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