# Path-Loss Characteristics at 3.4, 5.3, and 6.4 GHz in an Outdoor Microcell Environment

*Han-Shin Jo, Do-Youn Kim, Jong-Gwan Yook
Dept.of Electrical and Electronic Eng. Yonsei University
134 Sinchon-dong, Seodaemun-gu, Seoul, 120-749, Korea
Tel:+82-2-2123-4618, E-mail: jgyook@yonsei.ac.kr

## 1. Introduction

Present mobile communication systems have evolved by adding more and more system capabilities and enhancements, and the user will see a significant increase in capability through the future development of third generation mobile communication systems. Frequency bands below 6 GHz will likely be used for the fourth generation mobile communication systems[1]. In this paper signal strength measurements were conducted for unmodulated tones at 3.4, 5.3, and 6.4 GHz in order to characterize the behavior of narrowband signals in an outdoor microcell residential environment. The characteristics of path loss on the different residential area are thoroughly investigated. Also, it is compared with modified Hata model which is well known.

## 2. Propagation Measurements

CW measurements were performed at 3.4, 5.3, and 6.4 GHz frequency bands. The transmitter system is composed of a CW generator, power amplifier, and antenna. The receiver system comprises an antenna, low noise amplifier (LNA), and spectrum analyzer. The antenna output is fed by LNA, whose output is connected to a spectrum analyzer. Table 1 shows specifications of the measurement. A receiver antenna is mounted on the roof of a vehicle at a height of 2.0 m. Besides, a transmitting-receiving antenna system is formed by two identical half-wavelength dipoles featuring vertical polarization. Measurements are implemented in residential environment at the SEOUL and Bun-dang in Korea. For the residential area, the Bun-dang(Area A), the test routes and the transmitter are plotted in the map that is depicted in Fig. 1-(a). The transmit antenna has a height of 19 m which is mounted on the top of the building of 5 stories, when transmitter is surrounded by houses 4 stories(15 m). Therefore the height of antenna is situated at higher position than neighboring houses. The receiving vehicle traveled on streets with an average speed of approximately 6 m/s and six data points were recorded at the spectrum analyzer per one second. Distance between the transmitter and the receiver is increased up to 500 m.

In the residential area at the SEOUL(Area B), the test routes and the transmitter are described on

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the map as plotted in Fig. 1-(b). The height of transmit antenna is 50 m on the top of the apartment 15 stories. Transmitter location is under the apartment of 15 stories apartment existing circumstance. This explains that the surrounding apartment is lower than the antenna. The distance between the transmitter and the receiver is up to 1200 m. The receiving vehicle is covered with same way as it was done in area A. The recorded data were streamed to computer hard disc for later processing.

Table 1. Specifications of the measurement.

| | Frequency (GHz) | | |
|---|---|---|---|
| | $f_c$ =3.4 | $f_c$ =5.3 | $f_c$ =6.4 |
| CW Generator output power (dBm) | -20 | 10 | -10 |
| Power Amp output power(dBm) | 28 | 26 | 28 |
| LNA gain (dB) | 35.7 | 37.6 | 35.2 |

**3. Path Loss Characteristics**

In the wireless radio propagation channel, the received signals are fluctuated. From received powers averaged over these fluctuations path loss can be modeled as [2]:

$$PL(d)[dB] = \overline{PL}(d_0) + 10n\log\left(\frac{d}{d_0}\right) + X_\sigma \quad (1)$$

where $n$ is the path loss exponent which indicates the rate at which the path loss increasing with respect to distance, $d_0$ is the close-in reference distance which is determined from measurements close to the transmitter, and $d$ is the T-R separation distance. The shadowing loss $X_\sigma$ denotes a zero mean Gaussian random variable (in dB) with a standard deviation $\sigma$ (also in dB).

The measured path loss characteristics for the area A and B are presented in Fig. 2 and 3. The path loss distance dependency can be obtained by fitting the measured data with a minimum mean square error(MMSE) regression curve are shown. The modified Hata model is also plotted as compared to measured path loss characteristics. The modified Hata model (COST 231 Hata model) extends Hata model for use in 1.5-2.0 GHz frequency range[3]. The modified Hata model of the suburban area and urban area is explained with dashed lines and dash-dot lines, respectively. The parameters which characterize path loss in tested area are given in table 2.

The path loss exponents($n$) in area A are 3.1-3.2, which are smaller than those (3.5-3.9) in area B. The uneven value of path loss exponent between area A and B is clearly explained from the fact that the height of transmit antenna is less different to that of the surrounding building generates higher path loss exponent[4]. The standard deviation is observed between 6.56 dB and 7.70 dB which are similar to those typically encountered in cellular radio. Although the slope of regression curves for three frequencies in area A are smaller than that of a modified Hata model, path loss data is matched well with the modified suburban Hata model up to 1 km. In area B, at three frequencies, path loss shows good agreement of the slopes between regression curves and the modified suburban Hata model, and having the difference from 8 to 12 dB.

## 4. Conclusions

The study is intended to provide an understanding of how narrowband signals propagate in two kinds of residential environments. Measurements are performed at the frequencies of 3.4, 5.3, and 6.4 GHz. Though the slope of regression curves for three frequencies in area A are smaller than that of a modified Hata model, path loss data match the modified suburban Hata model fairly well up to 1 km. The slope of regression curves for three frequencies in area B is in good agreement with the modified suburban Hata model. However regression curves predicts 8-12 dB more path loss.

Table 2. Path Loss exponents and standard deviation

| | Area A | | Area B | |
|---|---|---|---|---|
| | Pass Loss Exponent(n) | Standard Deviation(σ) | Pass Loss Exponent(n) | Standard Deviation(σ) |
| 3.4 GHz | 3.13 | 7.03 | 3.90 | 7.70 |
| 5.3 GHz | 3.23 | 7.11 | 3.50 | 6.56 |
| 6.4 GHz | 3.20 | 7.59 | 3.53 | 6.92 |

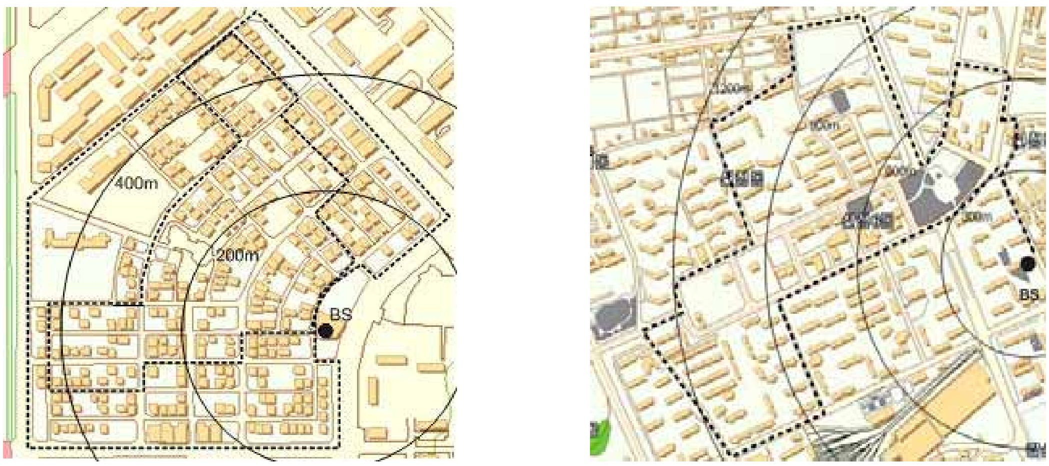
## References


[1] Questionnaire on possible Terrestrial Candidate Frequency Bands for the Future Development of IMT-2000 and System beyond IMT-2000 (Document 8F/TEMP/158)

[2] Theodore S. Rappaport, *Wireless Communications Principles and Practice*, Prentice Hall, 1996.

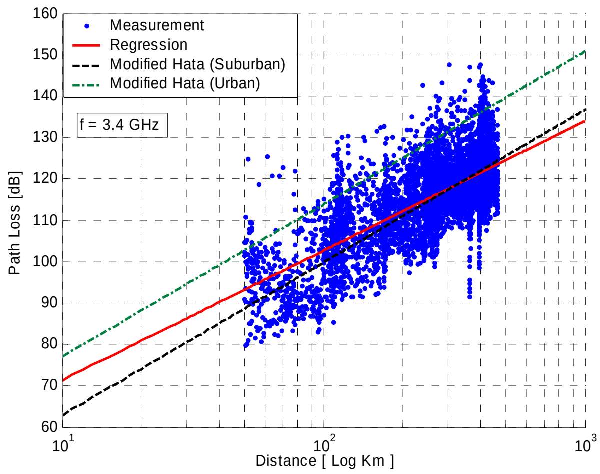
[3] EURO-COST 231, "Urban Transmission Loss models for Mobile Radio in the 900 and 1800 MHz Bands," Revision 2, The Hague, September 1991.

[4] Dongsoo Har, Howard H. Xia, Henry L. Bertoni,"Path-Loss Prediction Model for Microcells," IEEE Transactions on Vehicular Technology, vol 48, No. 5, September 1999.

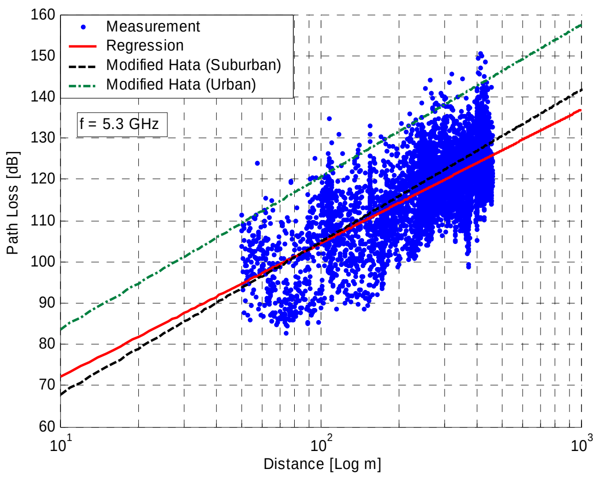




(a) Area A (b) Area B

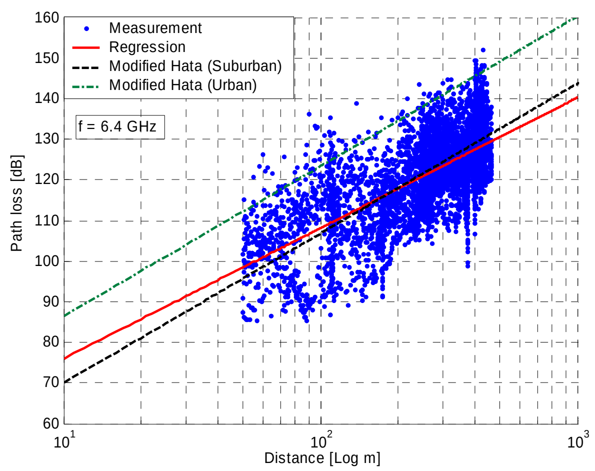
**Fig.1**. Measurement routes and BS positions at Area A and B.




(a) $f_c$ =3.4 GHz

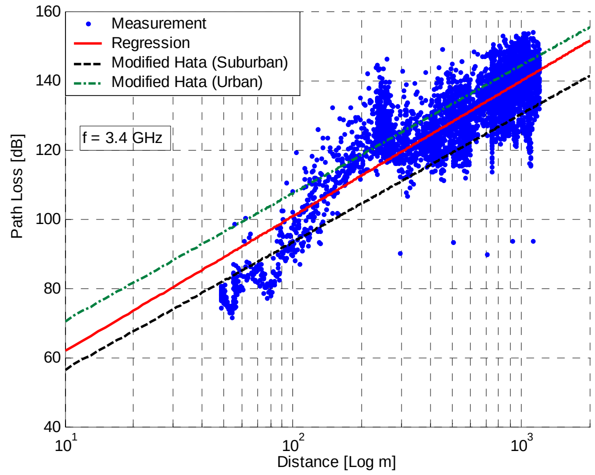



(b) $f_c$ =5.3 GHz

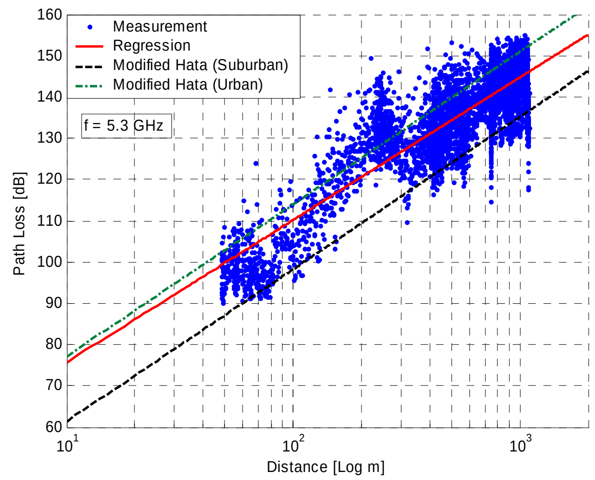



(c) $f_c$ =6.4 GHz

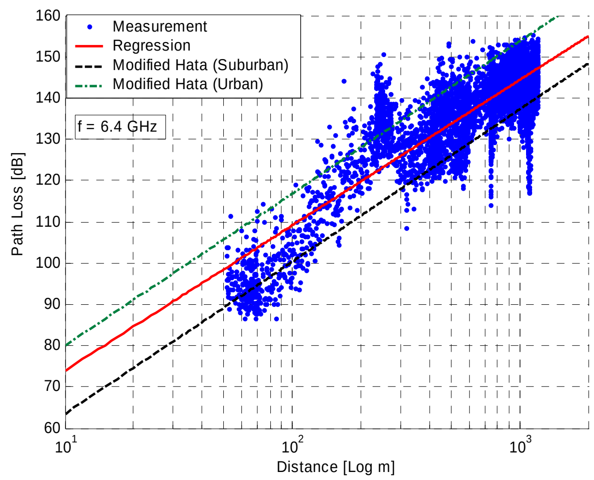
**Fig.2**. Path Loss at Area A




(a) $f_c$ =3.4 GHz




(b) $f_c$ =5.3 GHz




(c) $f_c$ =6.4 GHz

**Fig.3**. Path Loss at Area B.