THE EFFECT OF RECEIVING ANTENNA HEIGHT ON TEMPORAL FADING CHARACTERISTICS IN FIXED-TO-FIXED RADIO PROPAGATION CHANNEL

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Abstract

In fixed-to-fixed channel, it is widely assumed that the channel is stationary in time for above rooftop LOS propagation. This assumption is based on the fact that surrounding buildings are the main cause of multipath fading. However, the channel become quasi-stationary in time especially at lower receiving height (below rooftop) and for cases where moving objects are in the vicinity of receiving antenna. The effect of different receiving heights on temporal fading in terms of dynamic fading range for fixed-to-fixed channel is addressed in this paper.

I. Introduction

The need for Fixed Wireless Access (FWA) in providing fixed services especially in developing countries has been widely recognized in ITU-R. FWA also known as Wireless Local Loop (WLL) and Radio Local Loop (RLL) [1]. In fact, there are various fixed wireless access applications being in used at various frequency bands from few GHz up to several tens of GHz such as Local Multipoint Distribution Systems (LMDS) and Microwave Multipoint Distribution Systems (MMDS). These applications are having almost similar type of radio propagation channel, a fixed-to-fixed radio propagation channel. At frequencies above ten GHz the effect of rain is becoming more severe. However, the following work is conducted at 2 GHz frequency.

In FWA environment, the radio propagation channel is usually assumed to be stationary in time if LOS exists between transmitting and receiving antennas. The multipath propagation is mainly caused by surrounding non-moving objects such as buildings [2]. Therefore, fading in term of dynamic fading range in this case is below 6 dB as shown in the following section. However, the channel becomes quasi-stationary for receiving antenna below rooftop level. This is because moving vehicle especially big trucks and buses in the vicinity of receiver have contributed toward multipath fading [3]. This can be observed as deeper fluctuation in received CW signal.

In this paper, it is assumed that the receiving antenna is fixed outside a building either on wall or on roof. However, in some applications, the receiving antenna is fixed inside the building. The following sections describe in detail on measurement conducted in suburban area. Basically, it consists of four sections, 1) introduction, 2) measurement, 3) analysis & discussion, and finally a conclusion.

II. Measurements

A. Measurement setup

The transmitter used in this measurement has been constructed using Hewlett Packard 8657B signal generator and power amplifier. The signal generator is capable of generating CW signal at 2 GHz. The selection of CW carrier frequency at 2 GHz was made as the initial aim of this measurement is to study the application of FWA in International Mobile Telecommunication-2000 (IMT-2000), where 2 GHz is about the center of IMT-2000 frequency band. Discone antennas with frequency range 1.7-2.3 GHz and gain 2.2 dBi were used at both transmitting and receiving sides. The transmitting base was setup at the center of the residential. The height of the transmitting antenna is 19 m.

The receiver on the other hand was mounted on an adjustable mast with maximum height 10 m. The receiver is actually a modified commercial receiver that consists of a down converter, field strength meter and a personal computer for data acquisition purpose. CW signal level was monitored at the field strength meter. The CW signal levels were then digitised at sampling rate 100 Hz and stored on hard disk.

B. Field measurement

The aim of this measurement is to investigate the temporal fading characteristics in LOS and obstructed paths for suburban residential areas. The measurements were conducted at three different locations indicated as location A, B and C. In the first two locations the radio propagation path is obstructed by double story buildings with rooftop level 8.5 m. While location C is located at an opened area where the path between the transmitter and the receiver is totally unobstructed. All these three locations are located at roadside as shown in Fig.1.

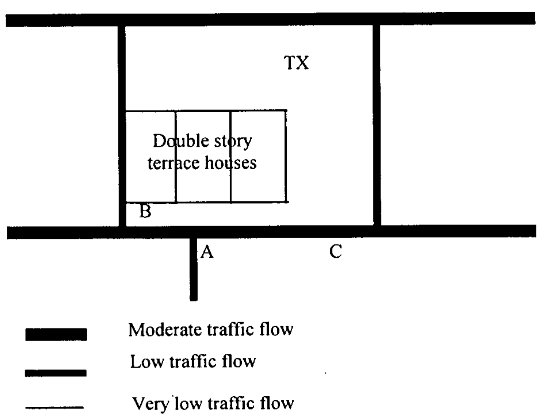


Fig.1. Location of transmitter (TX) and measurement locations (A, B, and C).

At each location, the receiver is fixed at a position. The CW signal is then monitored at the receiver for a period of 10 minutes at a desired receiving antenna's height. The data is recorded on hard disk. After each measurement, the receiving antenna's height is adjusted to another height before the next measurement begins. The measurement was repeated for the receiving antenna's height from 3 m to 10 m. The receiving height from 3 m up to 10 m was selected in order to investigate the temporal fading characteristics for radio propagation above rooftop level and below rooftop level.

Measurement at location C is used to compare with measurements conducted at location A and B in order to investigate the difference in temporal fading characteristics between LOS and obstructed path for receiving height below rooftop level.

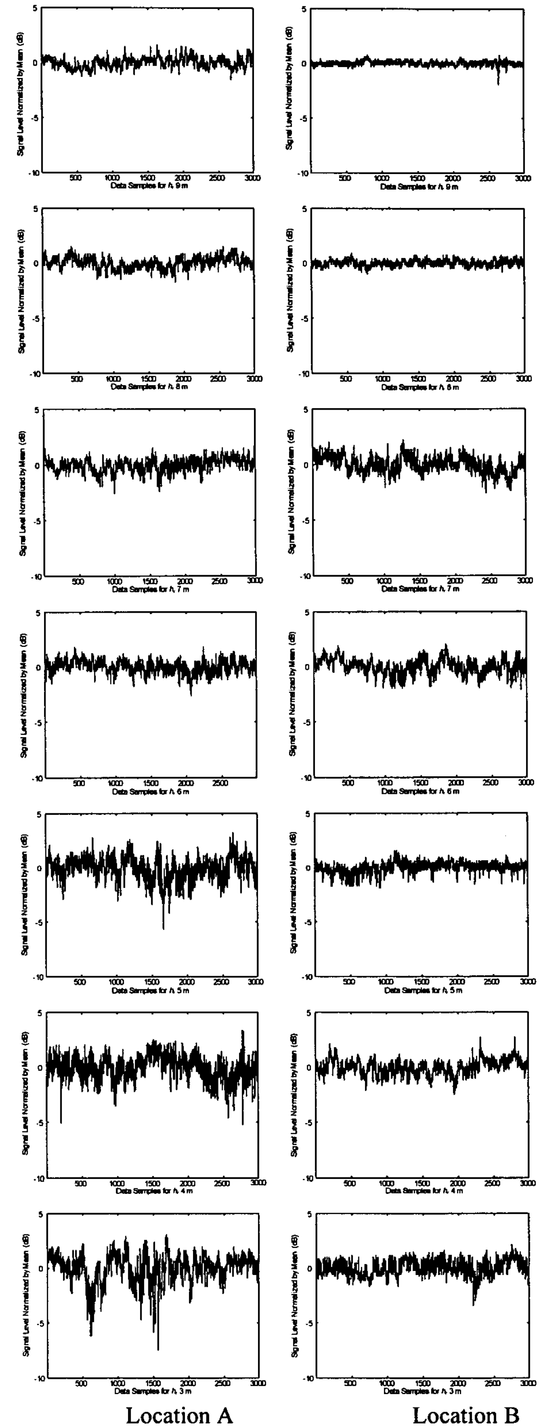


Fig.2. Recorded CW signals in 30s for each receiving height, h_r from 3 m to 9 m at location A and B.

III. Data Analysis & Discussion

A. Fading dynamic range

One of the important parameters to investigate the temporal fading characteristic is the fading dynamic range or the range of fluctuation [4]. It is actually the difference between minimum value and maximum value of fading CW signal [5]. Fig.2 shows the recorded CW signal at location for receiving height, h_r from 3 m to 10 m for a period of 30s or 3000 sample data. Fig.3 indicates that fading dynamic range for receiving above average rooftop level is less than 6dB and 15dB for a receiving height below average rooftop level. Fig.4 shows two recorded CW signal for h_r 5 m and 3 m at location C (LOS). It is clearly indicated that the dynamic fading range is relatively small as compared with location A and B except for the deep fluctuation.

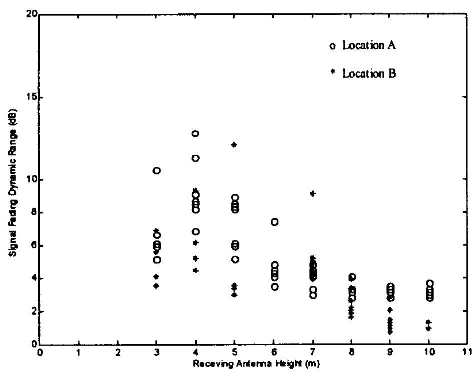
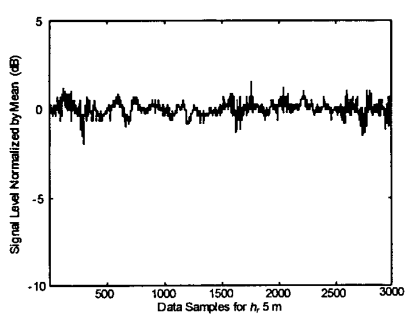
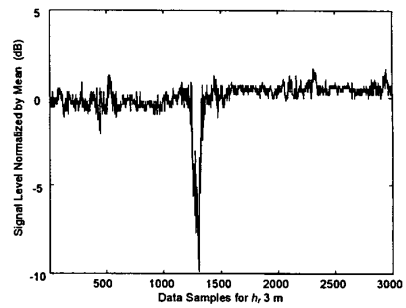


Fig.3. Fading dynamic range of location A and B.



(a)



(b)

Fig.4. Recorded CW signal for h_r 5 m and 3 m at location C.

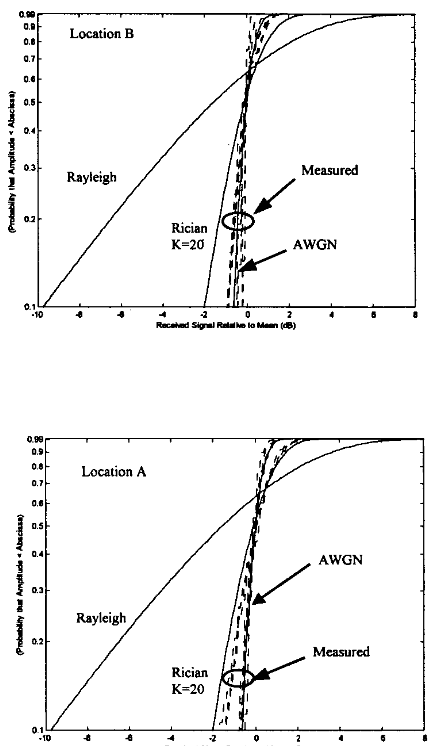


Fig.5. Cumulative distribution function (CDF) of received CW signal at different receiving heights, h_r.

B. CDF analysis

Analysis of amplitude fading distribution reveals that the cumulative distribution function (CDF) of received CW signals at all heights follow Gaussian distribution with different standard deviation as indicated in Fig.5. It can be concluded that this is an additive white Gaussian noise (AWGN) channel [6].

IV. Conclusions

The observed fading dynamic range for h_r above h_{roof} is less than 6 dB. However, the recorded maximum fading dynamic range is greater than 6 dB but smaller than 15 dB for h_r below h_{roof}. On the other hand, the CDF analysis indicates that CDF of received signal is varying within Gaussian distribution and Rician CDF distribution with K factor 20.

References

[1] "Wireless Access Local Loop," Handbook on Land Mobile (including wireless access) Vol. 1, ITU, Nov. 1996.

[2] H. Hashemi, "The indoor radio propagation channel," Proc. Of the IEEE, Vol. 81, pp. 943-968, July 1993.

[3] H. R. Anderson, "A ray-tracing propagation model for digital broadcast systems in urban areas," IEEE Trans. Broadcasting, vol. 39, pp. 309-317, Sept. 1993.

[4] R. J. C. Bultitude, S. A. Mahmoud, and W. A. Sullivan, "A comparison of indoor radio propagation characteristics at 910 MHz and 1.75 GHz," IEEE J. Select. Areas Commun., vol. 7, pp. 20-30, Jan. 1989.

[5] H. Hashemi, M. McGuire, T. Vlasschaert, and D. Tholl, "Measurements and modeling of temporal variations of the indoor radio propagation channel," IEEE Trans. Veh. Technol. vol. 43, pp. 733-737, Aug. 1994.

[6] W. C. Y. Lee, "Mobile communications engineering," Second edition, McGraw-Hill, pp. 563-565, 1998.