4C4-3

Experimental Investigations on Radio Propagation Characteristics in the 2.4 GHz and 5 GHz Bands in a Wooden Two-storied House

#Tsutomu Sakata, Atsushi Yamamoto, Hiroshi Iwai, and Koichi Ogawa
Network Development Center, Matsushita Electric Industrial Co., Ltd.
1006, Kadoma, Kadoma City, Osaka, 571-8501 Japan
E-mail: sakata.tstutomu@jp.panasonic.com

1. Introduction

The wireless LAN with MIMO technique has received considerable attention in resent years for its potential application to high-data rate radio communications in an office and a residential house. So far, there have been various investigations of radio propagation characteristics in indoor propagation environments [1]-[4]. In reference [3], the propagation characteristics in the 5 GHz band were measured in a residential house containing furniture such as beds, a sofa and tables by using a spatial scanner. Furthermore, the propagation characteristics between the first floor and the second floor in a two-storied house at 5.06 GHz were examined [4]. However, there have been few studies to investigate frequency characteristics of radio propagation in a house in detail.

This paper presents the propagation tests in the 2.4 GHz and 5 GHz bands between floors in a wooden two-storied house. Instantaneous variations in a cross-polarization power ratio (XPR) were measured using a spatial scanner. We measured not only the propagation characteristics in the first floor but also the propagation characteristics between the first floor and the second floor. From these experiments, we will show the frequency characteristics of XPR between floors in a Japanese two-storied house.

2. Measurement environment

The propagation experiments were conducted in a two-story residential house. A plan view of the house under test is illustrated in Fig. 1. The child's room on the second floor was located right above the living room on the first floor. The measurement area in the living room was mostly in LOS environments in the proximity of the transmitting antenna. With regard to the child's room, the measurement was carried out in NLOS environments because of the ceiling of the first floor between the transmitting and receiving antennas. A vertically polarized wave was radiated from a half-wavelength dipole, located on a table between the kitchen and the living room on the first floor. A receiving antenna was mounted on a spatial scanner in the living room and child's room. The spatial scanner can move the receiving antenna in the distance of 2.5 m along the x-axis with a sampling interval of 1 mm. The transmitted power was 0 dBm and the operating frequencies were 2.4 GHz and 5.06 GHz. Fig. 2 depicts the experimental setup. In Fig. 2, the heights of the transmitting and receiving antennas were 1 m from the floor. A half-wavelength dipole and a slot dipole were used as the receiving antenna for the vertical and horizontal polarizations, respectively. The instantaneous XPR can be determined as a power ratio of the vertically-polarized wave to the horizontally-polarized wave at each sampling step. A network analyzer was used for a transmitter and a receiver to obtain the amplitude and phase of the received signal.

3. Measured results

Figs. 3 and 4 show the instantaneous variations in received power of the vertically and horizontally polarized waves at 2.4 GHz and 5.06 GHz in the living and child's rooms. The received signal was corrected for the losses of the cables and the gain of the amplifier. It is observed from Figs. 3 and 4 that there are several deep local minima in the received powers. Comparison between the results at 2.4 GHz and 5.06 GHz indicates that the distance between the local minima at 5.06 GHz is shorter than that at 2.4 GHz because of its shorter wavelength. Moreover, it is found that the

ISBN: 978-4-88552-223-9 C3055©IEICE

average received powers *Pr* at 5.06 GHz, listed in Tables 1 and 2, are smaller than those at 2.4 GHz since the propagation loss in free space becomes larger with an increase in frequency.

Figs. 5 and 6 show the instantaneous variation in XPR at 2.4 GHz and 5.06 GHz in the living and child's rooms. From the figures, the values of XPR are varied from -30dB to 40dB. Fig. 7 depicts the probability distributions of the instantaneous XPR of the living and child's rooms. It is observed from Fig. 6 that the probability distributions of XPR at both frequencies approximately follow Gaussian distributions. Tables 1 and 2 also give the average values and standard deviations σ of the instantaneous XPR at 2.4 GHz and 5.06 GHz. As can be seen from the tables, the average values and the values of σ at 2.4 GHz are larger than those at 5.06 GHz. This indicates that the waves in the 5 GHz band have a greater rotation of the polarization than those in the 2 GHz band since the waves in the 5 GHz band are more scattered than those in the 2 GHz band. Furthermore, it is found that the average values of the instantaneous XPR in the child's room on the second floor are smaller than those in the living room on the first floor in both frequency bands, whilst the values of σ in the child's room are larger than those in the living room. In the propagation between the floors, the waves penetrating through the ceiling can be easily scattered, and then part of the waves scattered are rotated from the vertical polarization to the horizontal polarization.

4. Conclusion

Experimental investigations on the radio propagation characteristics at 2.4 GHz and 5.06 GHz were performed in a wooden two-storied house. It is found from the propagation tests that the probability distributions of the instantaneous XPR at both frequencies approximately follow Gaussian distributions. Furthermore, we found that the average values and the standard deviations of the instantaneous XPR at 2.4 GHz are larger than those at 5.06 GHz since the waves in the 5 GHz band have a greater rotation of polarization than those in the 2 GHz band. With respect to the propagation between the floors, it is found that the average values of XPR of the propagation between the floors are smaller than those in the same floor at both frequencies since the waves penetrating through the ceiling can be easily scattered.

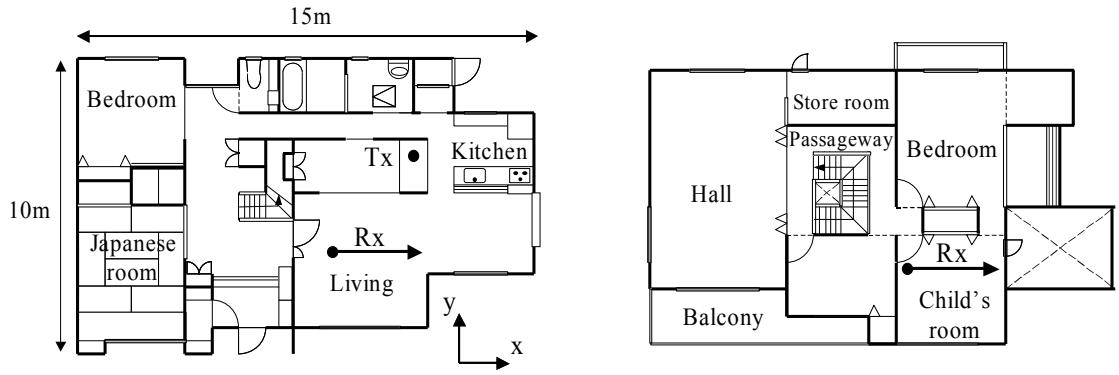
References

[1] L. C. Lukama and D. J. Edwards, "Analysis of Wideband Indoor Propagation Measurements at 2.4GHz," proc. IEEE ICAP 2003, pp. 509-512, vol. 2, April 2003.

[2] D. Chizhik, J. Ling, and R. A. Valenzuela, "The Effect of Electric Field Polarization on Indoor Propagation," IEEE ICUPC, vol.1, pp.459-462, 5-9 Oct. 1998.

[3] K. Mizutani, K. Sakaguchi, J. Takada, and K. Araki, "Real-Time MIMO Channel Measurement using 5GHz 4-by-4 MIMO-OFDM Hardware, " in Tech. Rep. of IEICE, WBS2004-117, AP2004-298, RCS2004-385, MoMuC2004-168, MW2004-295, Mar. 2005.

[4] H. Iwai, T. Sakata, A. Yamamoto, K. Ogawa, K. Sakaguchi, and K. Araki, "3-D Angular Spectrum Measurements in a Residential House at 5GHz," ISAP2006, vol.1, FB2, Nov. 2006.



(a) First floor (b) Second floor

Figure 1: Plan view of the house.

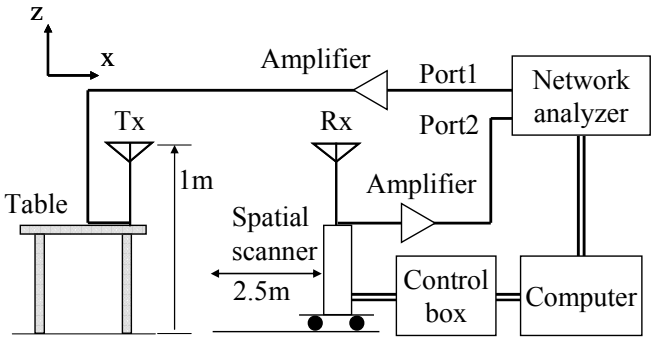
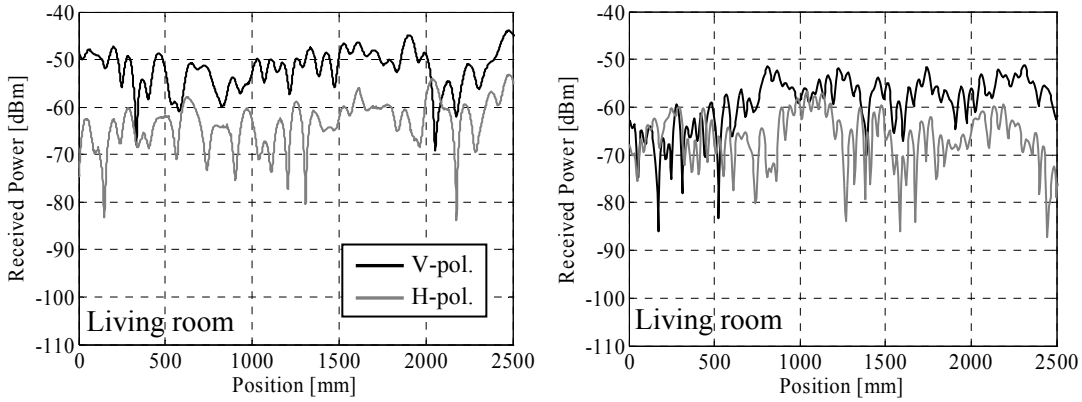
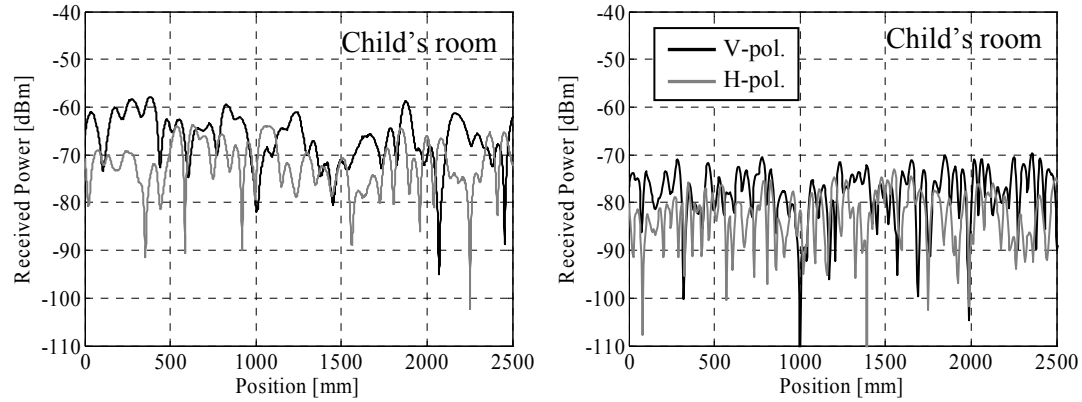


Figure 2: Experimental setup.



(a) 2.4 GHz (b) 5.06 GHz

Figure 3: Instantaneous variations in received power in the living room on the first floor.



(a) 2.4 GHz (b) 5.06 GHz

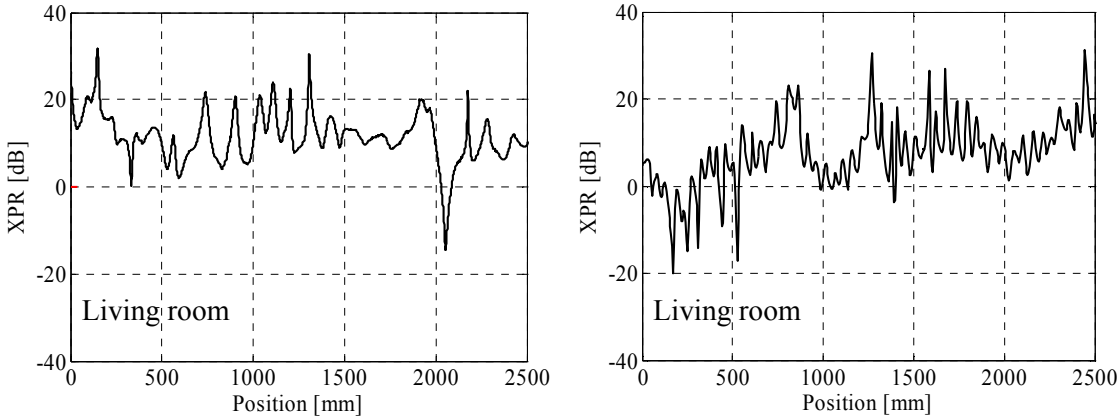
Figure 4: Instantaneous variations in received power in the child's room on the second floor.

Table 1: Measured results at 2.4 GHz.

	Polarization	Average P_r [dBm]	Average XPR [dB]	σ [dB]
Living room	Vertical	-50.5	10.5	6.9
	Horizontal	-61.0		
Child's Room	Vertical	-64.5	5.3	7.3
	Horizontal	-69.8		

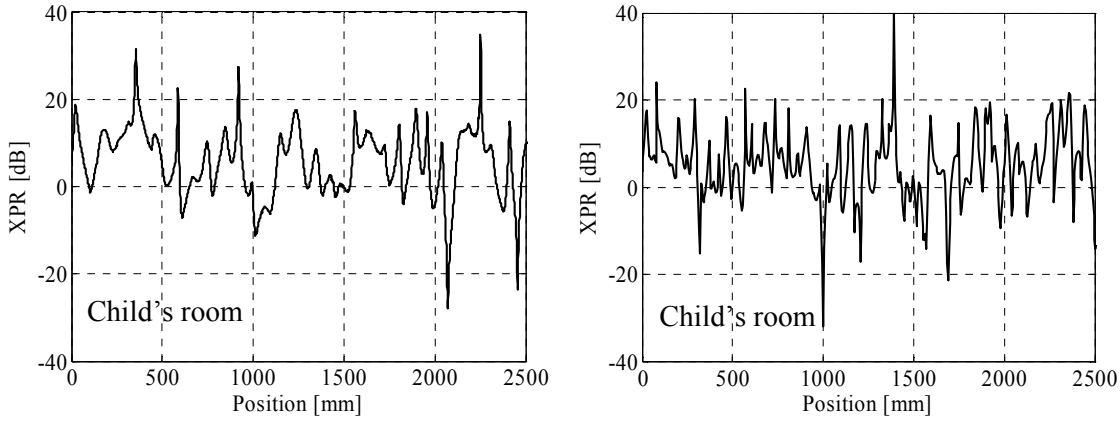
Table 2: Measured results at 5.06 GHz.

	Polarization	Average P_r [dBm]	Average XPR [dB]	σ [dB]
Living room	Vertical	-56.8	7.5	5.9
	Horizontal	-64.3		
Child's Room	Vertical	-75.9	4.6	6.5
	Horizontal	-80.3		



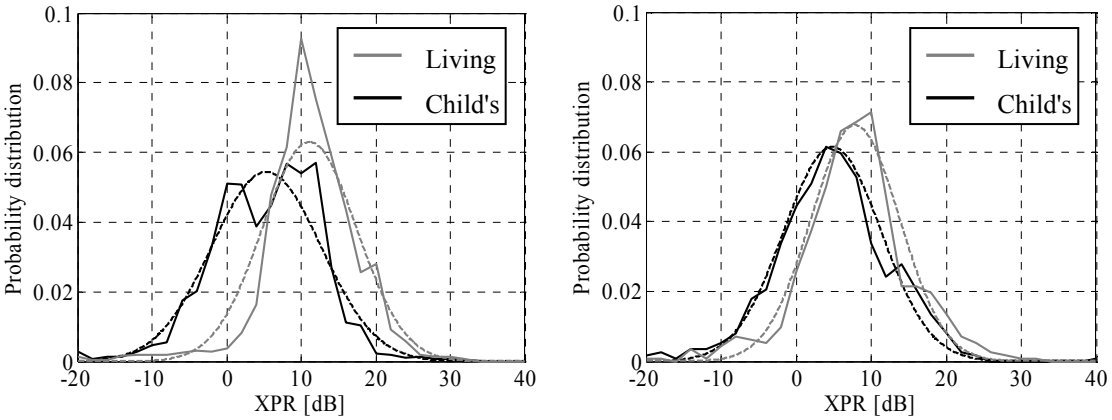
(a) 2.4 GHz (b) 5.06 GHz

Figure 5: Instantaneous variations in XPR in the living room on the first floor.



(a) 2.4 GHz (b) 5.06 GHz

Figure 6: Instantaneous variations in XPR in the child's room on the second floor.



(a) 2.4 GHz (b) 5.06 GHz

Figure 7: Probability distribution of XPR.