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Measurement of Radio Propagation Characteristics for Inter-Vehicle Communication in Urban Areas

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1. Introduction

In the field of Intelligent Transport Systems (ITS), inter-vehicle communication systems are actively researched for the purpose of decreasing the number of traffic accidents. In particular, reduced visibility due to buildings and vehicles is a significant cause of right-turn accidents and head-on accidents. The Inter-Vehicle Communication system enables the position of a vehicle to be transmitted to other vehicles, so it is expected to provide a means by which to prevent traffic accidents. At locations in which the system will actually be used, such as urban intersections in which several cars are present, communication using an antenna mounted low on the vehicle cannot be avoided. In such cases, buildings and other vehicles exist as shadowing objects between transmitting and receiving vehicles. Therefore, it is expected that surrounding objects will strongly influence the received power. For such reasons, it is necessary to investigate radio propagation characteristics in the inter-vehicle communication environment.

Urban radio propagation characteristics and propagation loss predictions have been investigated in several frequency bands [1] [2] [3]. However, the influence of nearby vehicles has not been considered because the assumed mounting of the transmitting antenna was higher than the vehicle height. Although there has been interest in a 5.8-GHz safety system in Japan [4], it has been reported that shadowing by nearby vehicles greatly influences the received power change in this frequency band [5].

Higher reliability and response are required for safety systems than for entertainment systems. Therefore, a system design that considers the propagation characteristics in Non-Line-of-Sight (NLOS) and the influence of vehicles is necessary. A simple propagation model to evaluate the communication quality and the effect of the introduction of the safety system is also needed.

In the present paper, measurement of the propagation characteristics in an urban intersection with a low antenna mounting (2 meters above the ground) is presented. From the measurement data, the Line-of-Sight(LOS) and NLOS propagation characteristics and the influence of surrounding vehicles are evaluated.

2. Description of measurement

Figure 1 is a map of the measurement location, and Table 1 lists the measurement parameters. At the measurement location, buildings were built along both sides of the road. The transmitter was set at one location for the LOS measurement and three locations for the NLOS measurement. The transmitter was stationary, and the receiver was mobile. The received power was measured. Transmitting and receiving antennas were placed on the roof of the vehicles, as shown in Fig. 2. The heights of the antennas were fixed at 2.08 m and 1.72 m, because the application was assumed to be to Inter-Vehicle Communication. Frequencies of 2.552 GHz and 5.015 GHz were used, and authorization was obtained from the Ministry of Internal Affairs and Communications.

In addition, in order to evaluate the influence of surrounding vehicles, we performed measurements during the daytime (13:00-16:00) and the nighttime (1:00-5:00). The measurement location during the daytime is crowded with vehicles, and vehicles are located in front of and behind the measurement vehicle. In contrast, few vehicles were present during the nighttime.

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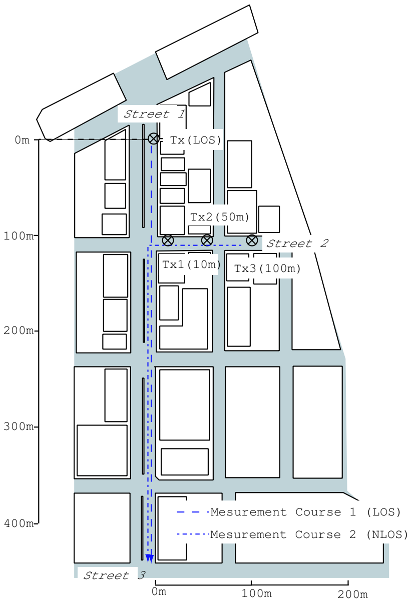

Figure 1: Measurement Environment

Table 1: Measurement Parameters

Antenna	Dipole antenna
Gain	2.15 dBi
Polarization	Vertical
Modulation	CW
Transmission power	+10 dBm
Frequency	2.552 GHz 5.015 GHz
Tx antenna height: ht	2.08 m
Rx antenna height: hr	1.72 m

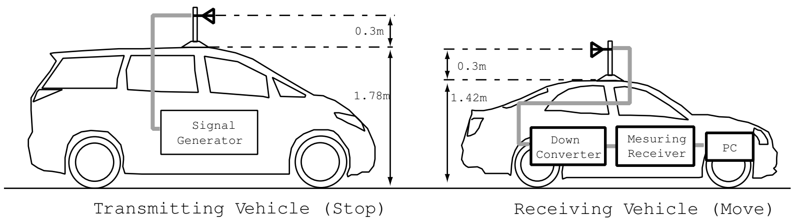

Figure 2: Measurement Vehicles

3. Measurement Results

The LOS and NLOS measurement results are shown. The receiving power is given as the median value 2.5 m in front of and behind the receiving point. In the following graphs, the vertical axis indicates the receiving power, and the horizontal axis indicates the distance from the transmitter.

3.1 LOS Results

In the LOS measurement, we used measurement course 1, and data was measured over approximately 400 m. Figures 3 and 4 show the LOS results of 2.552 GHz and 5.015 GHz, respectively. Linear fitting curves are shown corresponding to the measurement results in graphs and can be expressed as follows:

$$P_r = 10log_{10}d^a + b \quad (1)$$

The curves are shown by the two slopes on the boundary of d_b, which is the distance from the transmitter to the breakpoint [6], given by the following equations:

$$d_b = \frac{4h_t h_r}{\lambda} \quad (2)$$

In Figs. 3 and 4, the value of the decrement coefficient a of the nighttime results (non-vehicle) is 1.6 - 1.8 in the section from Tx to d_b and is 4.0 - 4.3 in the range from d_b. There results correspond approximately to the results of the general grand propagation characteristics. When the daytime results

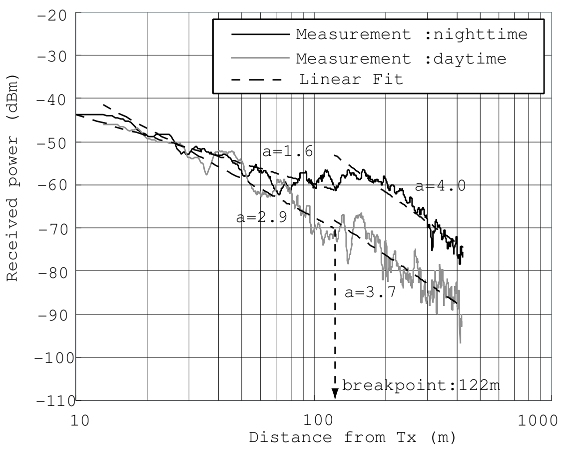

Figure 3: 2.552 GHz LOS Characteristics

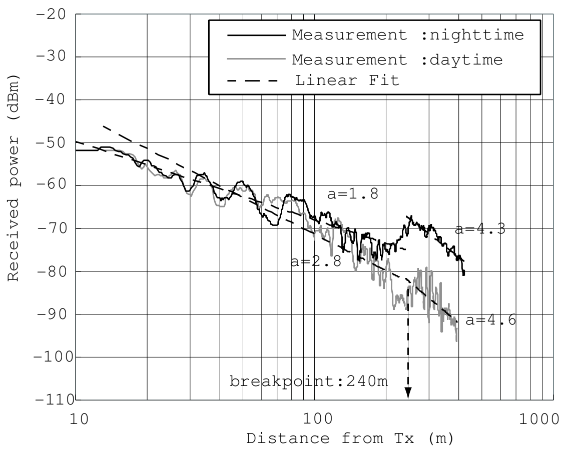

Figure 4: 5.015 GHz LOS Characteristics

are compared to the nighttime results, the received power corresponds in the range from Tx to d_b. In the range beyond d_b, the nighttime results are 10-20 dB higher than those for the daytime.

The reason for this is thought to be as follows. Typically, in the LOS environment, direct waves and road reflection waves are predominant of the received power. However, during daytime measurement, road reflection waves do not exist because there are several vehicles on the road. Therefore, direct waves cannot be strengthened in phase with other strong waves in the area beyond d_b.

3. 2 NLOS Results

In NLOS measurement, we used measurement course 2, which is the LOS environment from the starting point to the intersection and the NLOS environment after turning to the left at the intersection. The transmitter was set up from the intersection to 10 m, 50 m, and 100 m, respectively.

Figures 5 and 6 show the NLOS results for frequencies of 2.552 GHz and 5.015 GHz. Fitting curves are shown as two slopes on the boundary of LOS/NLOS. The values of the decrement coefficient *a* are calculated under the condition that the boundary of LOS/NLOS is defined as $d=0$. In Figs. 5 and 6, the value of coefficient *a* does not depend on the frequency or the distance from the transmitter and is almost constant.

Figures 7 and 8 show the influence of surrounding vehicles in the NLOS environment for frequencies of 2.552 GHz and 5.015 GHz. From Figs. 7 and 8, there is no difference in received power in the NLOS area, even if surrounding vehicles exist. These results indicate that surrounding vehicles do not influence the propagation characteristics in the NLOS area.

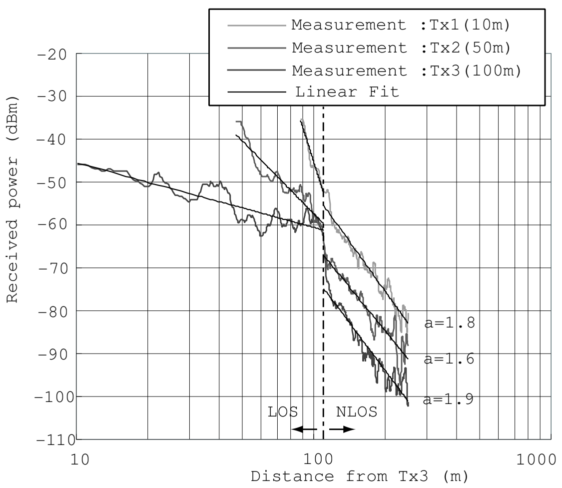

Figure 5: 2.552 GHz NLOS Characteristics

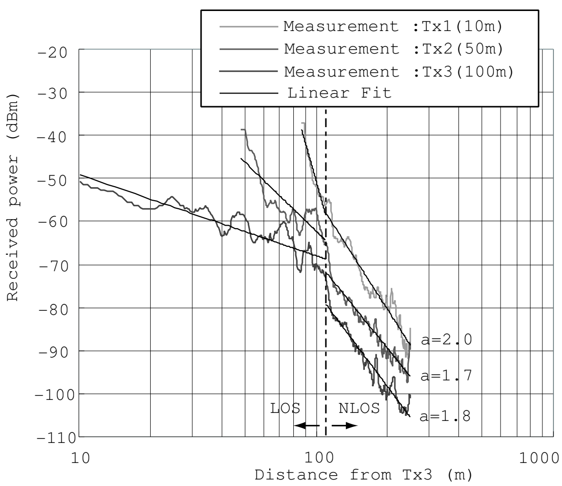

Figure 6: 5.015 GHz NLOS Characteristics

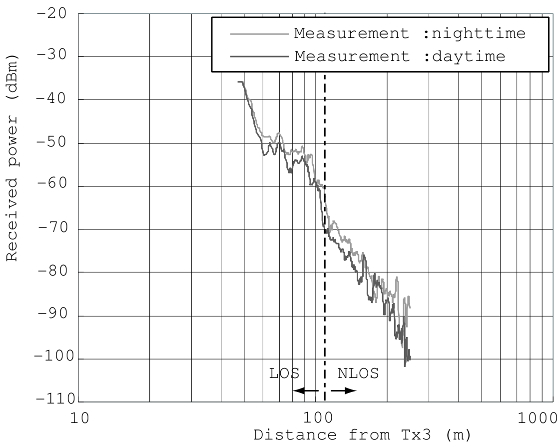

Figure 7: 2.552 GHz NLOS Influence of Surrounding Vehicles

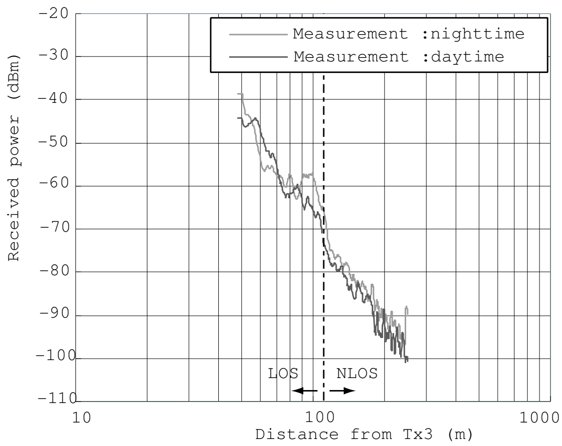

Figure 8: 5.015 GHz NLOS Influence of Surrounding Vehicles

4. Conclusions

The measurement of radio propagation characteristics for inter-vehicle communication in urban areas has been clarified with respect to the influence of surrounding vehicles in the LOS and NLOS environments. In the LOS environment, the received power was decreased by 10 - 20 dB as a result of the influence of surrounding vehicles. On the other hand, surrounding vehicles did not influence the received power in the NLOS environment. In addition, the NLOS results showed that the value of the decrement coefficient a does not depend on the frequency or the distance from the transmitter. In the future, it will be necessary to perform similar measurements in a suburban environment in which there are few buildings.

References

[1] Masatake Kaji, Akira AKEYAMA, "UHF-Band Radio Propagation Characteristics In Built Up Areas For Land Mobile System Using Low Antenna Height Base Station," IEICE Trans. Communications, Vol. J70-B, No. 5, pp. 602–610, 1987.

[2] Shinichi Ichitsubo, Teturou Imai, "Propagation Loss Prediction in Microcell with Low Base Site Antenna," IEICE Trans. Communications, Vol. J75-B-Ⅱ, No. 8, pp. 596–598, 1992.

[3] The ITU Radiocommunication Assembly, "Propagation data and prediction methods for the planning of short-range outdoor radio communication systems and radio local area networks in the frequency range 300 MHz to 100 GHz," Rec. ITU-R P.1411-1, 1999-2000.

[4] Kaoru Seki, Kiyohito Tokuda, Toshihisa Shimizu, "Characteristics of inter-vehicle information transmission using 5.8 GHz frequency," Proc. ITS World Congress, Nagoya, paper 3033, 2004.

[5] Andreas Richter, Tokio Taga, and Reiner Thoma, "Measurement and Analysis of Propagation Path Variations In a Street Micro-cell Scenario," IEICE Tech.Rep.Antennas Propagation, Vol. AP2002-102, pp. 7–14, 2002.

[6] H.H. Xia, H.L. Bertoni, L.R. Maciel, A. Lindsay Stewart, R. Rowe, "Radio Propagation Characteristics for Line-of-Sight Microcellular and Personal Communications," IEEE Trans. Antennas and Propagation, Vol. 41, No. 10, pp. 1439-1447, 1993.