

Analysis of Multipath Propagation Characteristics for Digital Terrestrial Broadcasting in UHF Band on Urban Street Using Ray Tracing Method

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1. Introduction

Recently, it is important to know the multipath radio wave propagation characteristics on urban street to realize a good receiving performance of the digital terrestrial broadcasting for cars. Furthermore, knowing the propagation characteristics is necessary to perform the experiment for the evaluation of MIMO terminal [1]. In non-line-of-sight multipath environments of urban street, it is generally assumed that a probability density function (pdf) of received signal power is given by the Rayleigh distribution [2]-[4]. However, it seems unclear whether above mentioned assumptions are satisfied in an actual urban street. In this work, radio wave propagation characteristics on urban street for the digital terrestrial broadcasting in UHF band are investigated using the ray tracing method.

2. Wave Propagation Analysis on Urban Roads for UHF Band

Figure 1 shows an outline view of wave propagation in urban area. As shown in the figure, radio waves come from various directions. In the case of non-line-of-sight, the probability density function (pdf) of a transmitted wave is assumed as the Rayleigh distribution,

$$p(r) = \frac{r}{\sigma^2} \exp\left(-\frac{r^2}{2\sigma^2}\right), \quad (1)$$

where σ^2 denotes the average received power. However, it seems unclear whether above mentioned assumptions are satisfied in an actual urban street.

In this work, we analyse the wave propagation characteristics on urban street for the digital terrestrial broadcasting by using the ray-tracing method.

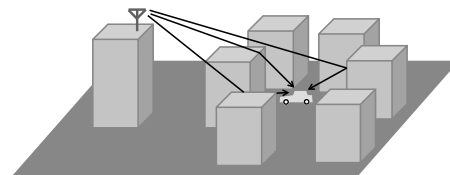


Figure 1: Wave Propagation in Urban Area

2.1 Urban Area Model

Figure 2 shows an urban area model. In this simulation, wave propagation characteristics are analysed for transmitter positions Tx1 and Tx2, respectively.

Table 1 shows the parameters used in this simulation. The material of road is set to dry asphalt [5]. The building wall is assumed to be made of the concrete with the electric constant of 1GHz recommended by ITU-R [6]. The frequency of transmitted wave is middle of the frequency

band of the digital terrestrial broadcasting in Japan. Table 2 shows the parameters used in this ray-tracing simulation.

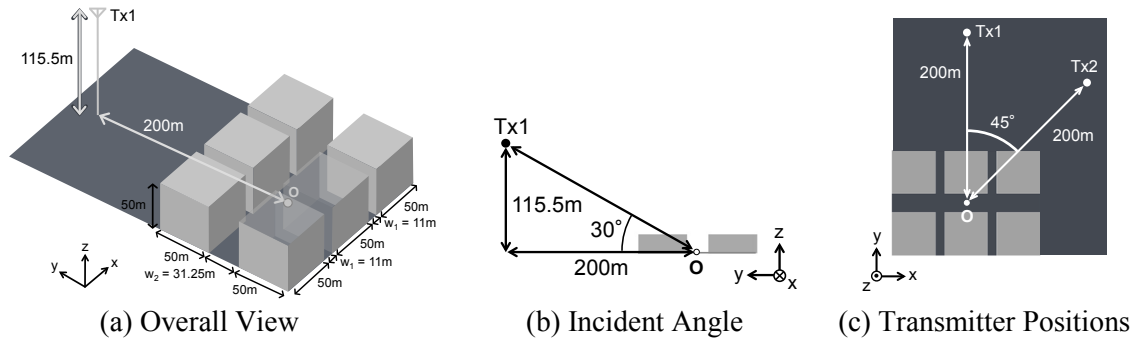


Figure 2: Urban Area Model

Table 1: Simulation Conditions

Transmitter	Frequency		590 MHz
	Polarization		Horizontal
Road	Width	w_1	11 m
		w_2	31.25 m
	Dry asphalt	ϵ_r	4.9
		σ	0.00761 S/m
Building	Height	h	50.0 m
	Concrete	ϵ_r	7.0
		σ	0.0473 S/m

Table 2: Ray-tracing Conditions

Number of ray	Transmitter	About 284 million
	Diffraction point	2000
Maximum number of reflections		10
Maximum number of diffraction		1
Diffraction coefficients		UTD method

3. Results

Figure 3 shows an observed plane of electric fields. The height of the observed plane is $z = 1.5$ m. This height corresponds to that of car rooftop.

Figure 4 shows the observation lane of cumulative frequency distribution of received power.

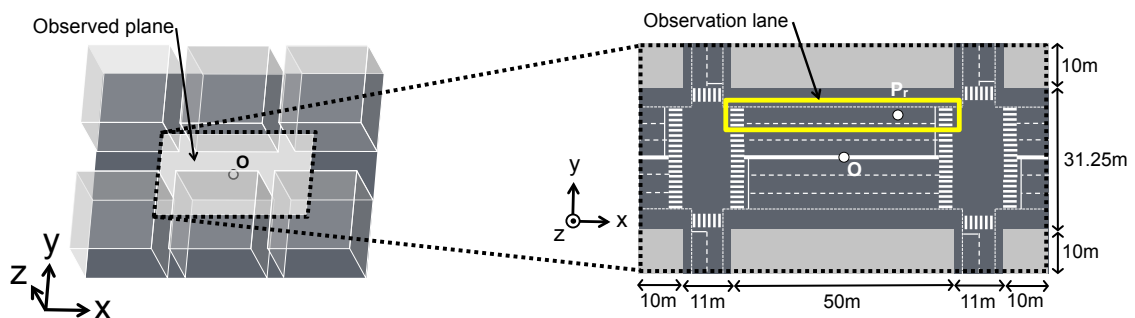


Figure 3: Observed Plane of Electric Fields

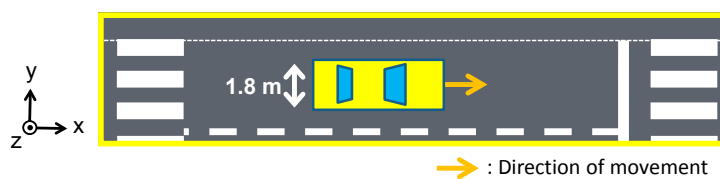


Figure 4: Observation Lane of Cumulative Frequency Distribution

3.1 Electric Fields Distribution on Urban Roads

Figure 5 shows the electric fields distribution in the observed plane for the case of each transmitter position. The electric fields distribution is normalized by the value at the point of transmitter.

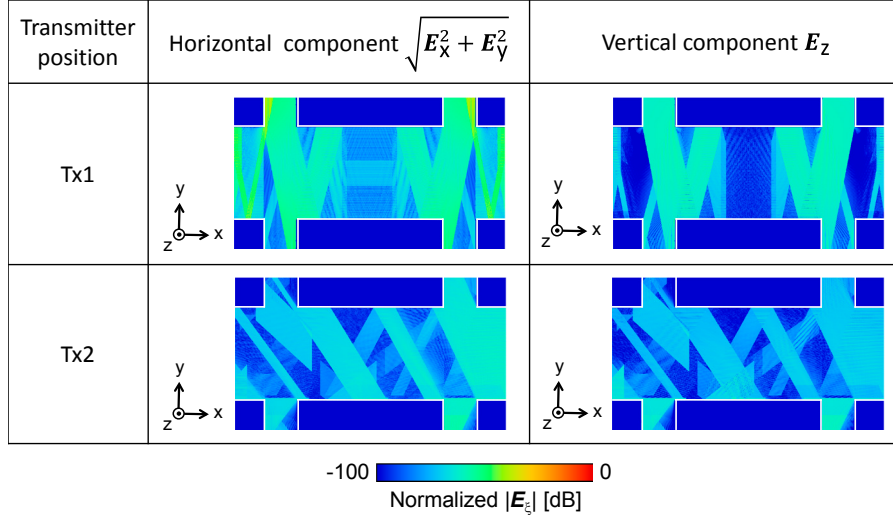


Figure 5: Electric Fields Distribution in Observed Plane

3.2 Arrival Direction Distribution at Receiving Point

Figure 6 shows the arrival direction distribution in a horizontal plane at a receiving point. As an example, the results at point P_r indicated in Fig. 3 are shown. A length of each vector denotes the normalized intensity. As shown in this figure, it seems that propagating waves mainly come from the building walls of both sides.

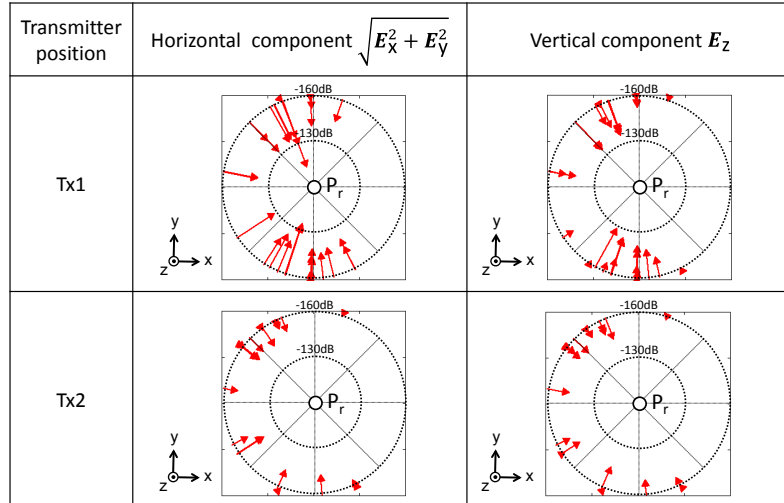


Figure 6: Arrival Direction Distribution in Horizontal Plane at Receiving Point P_r

3.3 Cumulative Frequency Distribution of Electrical Fields Intensity

Figure 7 shows the cumulative frequency distribution on the observation lane. Theoretical values of the cumulative distribution function of the Rayleigh distribution are obtained from Eq. (2).

$$F(r) = 1 - \exp\left(-\frac{r^2}{2\sigma^2}\right), \quad (2)$$

where σ^2 denotes the average received power. In both transmitter positions, it is seen that cumulative probability denotes the different tendency compared with the Rayleigh distribution.

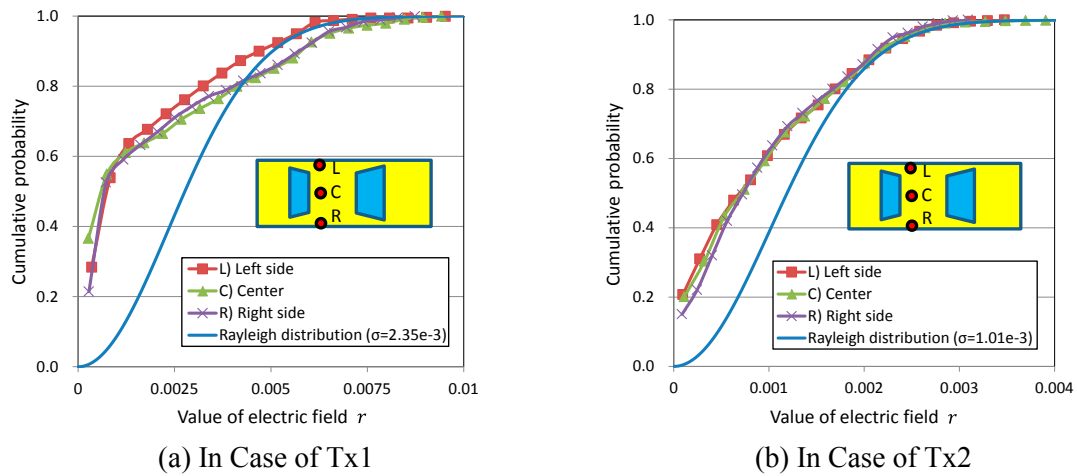


Figure 7: Cumulative Frequency Distribution on Observation Lane for Transmitter Positions

4. Conclusions

In this study, we analyse the radio wave propagation characteristics on urban street to realize a good receiving performance of the digital terrestrial broadcasting for cars. In this simulation, the ray-tracing method was used. As a result, it was found that the pdf of received wave does not strictly agree with the Rayleigh distribution.

In the near future, we plan to study the pdf of other models considering the position and height of transmitters, and building parameters.

Acknowledgments

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