ESTIMATION OF DELAY SPREAD IN MOBILE COMMUNICATION ENVIRONMENTS

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1. Introduction

Car antennas for mobile communications should be designed as characteristics of the signal received by the antennas in mobile communication environments become best. To realize such design of the car antennas, the author has proposed a method to estimate the received signal characteristics from the radiation pattern of the antennas[1]. The estimation method possesses the feature that some environmental conditions on a street such as building height and street width, as well as the radiation pattern, are considered.

In the estimation method, the received power, the fading spectrum and the delay spread which are averaged within an arbitrary region with about 1 km length on a street are objectives of estimation. The delay spread is a considerable received signal characteristic in the design of the car antenna suitable for wide-band mobile communications.

It has been already reported that the received power and the fading spectrum, estimated with the above method, agree well with those measured in the urban area[1]. However, it has not been confirmed that the delay spread is well estimated with the method. This paper discusses the applicability of the method to the estimation of the delay spread.

2. Estimation method for received signal characteristics

The characteristics of the signal received by the car antenna are calculated in the estimation method from both the radiation pattern of the antenna and the angular probability density distribution of radio wave arrival. Here, the distribution is calculated under the simplified environmental conditions as shown in Fig.1[2]. The rows of buildings along the street are substituted with the vertical conducting plates in Fig.1. Moreover, the street is assumed to extend infinitely. The conditions are expressed using some environmental parameters, such as the street angle ϕ ($0^\circ \leqq \phi \leqq 90^\circ$), the street width Wab, the cross street width Wc, the interval L of the cross streets and the mean building-heights Ha and Hb at the side A and the side B on the street, respectively. Thus, the environmental conditions can be easily considered using these environmental parameters in the estimation method.

3. Comparison between estimated and measured results

The applicability of the estimation method to the estimation of the delay spread is discussed in this section through the comparison between the estimated and the measured delay spreads.

The delay spread of each test course in Kyoto city as shown in Fig.2 was estimated using the environmental parameters of the corresponding test course as shown in Table 1. While the measured value (the measured delay spread) of the delay spread on each test course was obtained from the delay profiles measured on the corresponding test course[3]. A monopole antenna was used as a receiving antenna in the experiments.

Figure 3 shows the relation between the estimated and the measured delay spreads. The positive correlation between the former and the latter can be seen. However, the value of the estimated delay spread is small compared with that of the corresponding measured delay spread.

From the above results, it is found that the estimation method is difficult to apply to estimating the precise value of the delay spread. However, the method seems to be applicable to the analysis of the variation of the delay spread for the environmental conditions and the radiation pattern.

4. Effect of environmental conditions on delay spread

The estimation method for the received signal characteristics has the advantage that the environmental conditions can be easily considered. By using the method, analyzing the variations of the delay spread for the street angle and the street width is tried in this section.

4.1 Effect of street angle

Figure 4 shows the variation of the delay spread for the street angle. The result was estimated using the environmental parameters as shown in Table 2. Each of these parameters was obtained from averaging the corresponding parameters of all the test courses. It is found from Fig. 4 that the delay spread decreases with the increase of the street angle. This variation of the delay spread for the street angle can be seen also in the measured result as shown in Fig.5 although the measured data tend to slightly scatter.

4.2 Effect of street width

Figure 6 shows the variation of the delay spread for the street width. The variation was also estimated using the environmental parameters in Table 2. In the case of 5-degree street angle, the delay spread increases with the street width. While the delay spread hardly varies with the street width in the case of 85-degree street angle. Thus, the tendency of the variation of the delay spread for the street width in the small street angle region is different from that in the large street angle region. This difference appears also in the measured result as shown in Fig.7.

It is found from the preceding results that the estimation method is applicable to the analysis of the effects of the street angle and the street width on the delay spread.

5. Conclusion

The delay spread obtained using the estimation method for the received signal characteristics has been compared with the delay spread measured in Kyoto city. From the comparison, it has been found that the estimation method is applicable to the analysis of the effects of the environmental conditions on the delay spread, but the method is difficult to apply to estimating the precise value of the delay spread.

In future, the variation of the delay spread for the radiation patten will be analyzed using the method. Furthermore, the radiation pattern of the car antenna suitable for the wide-band mobile communications will be revealed on the basis of this analysis.

Acknowledgment

The author would like to thank Prof.F.Ikegami of Takushoku University, Prof.S.Yoshida and Dr.T.Takeuchi of Kyoto University for allowing him to use the data of the delay profile measured in Kyoto city. He also would like to acknowledge helpful comments of Dr.K.Nishikawa of Toyota Central Research and Development Labs.

References

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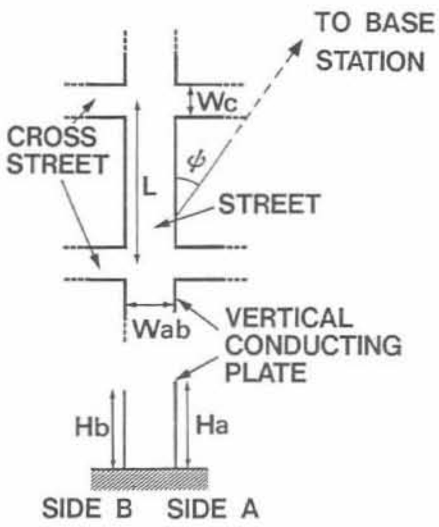

Fig.1 Simplified environmental conditions.

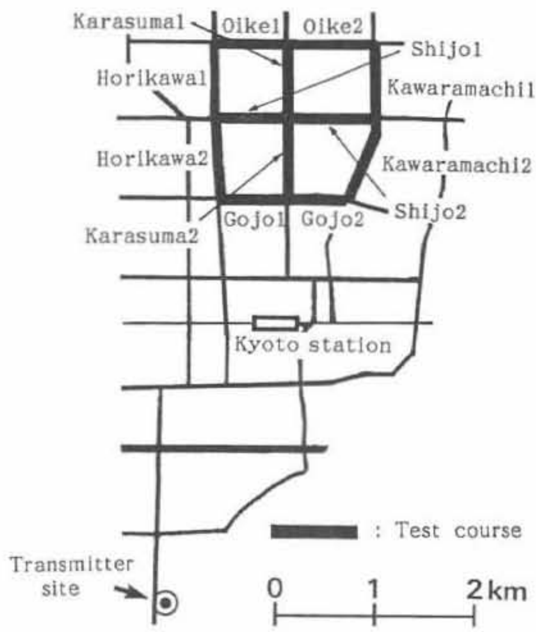

Fig.2 Test courses.

Table 1 Values of environmental parameters of each test course.

Test course	ϕ (°)	Wab(m)	Wc(m)	L(m)	Ha(m)	Hb(m)
HORIKAWA1	6	51	12	88	14	11
HORIKAWA2	9	51	15	93	14	11
KARASUMA1	13	29	16	89	23	23
KARASUMA2	16	29	17	93	30	26
KAWARAMACHI1	22	25	14	72	13	23
KAWARAMACHI2	5	24	17	99	19	20
OIKE1	81	50	14	54	14	14
OIKE2	73	50	11	57	22	15
SHIJO1	79	25	17	72	15	16
SHIJO2	70	25	10	64	23	19
GOJO1	78	50	13	50	21	15
GOJO2	71	50	12	57	13	12

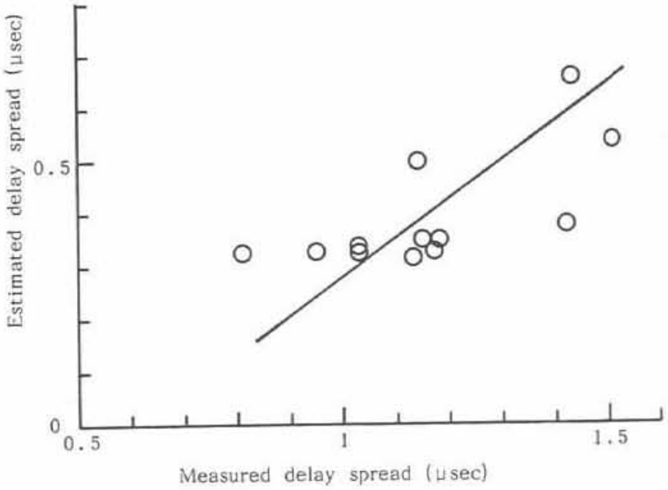

Fig.3 Relation between estimated and measured delay spreads ,and best-fit line.

Table 2 Values of environmental parameters.

Wab	38 m
Wc	14 m
L	74 m
Ha	18 m
Hb	17 m

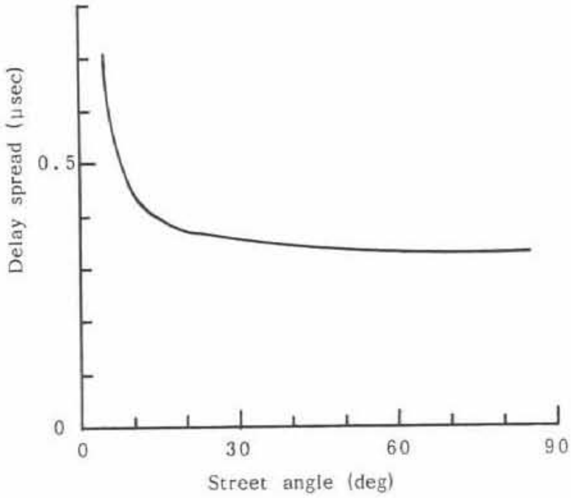

Fig.4 Variation of estimated delay spread with street angle.

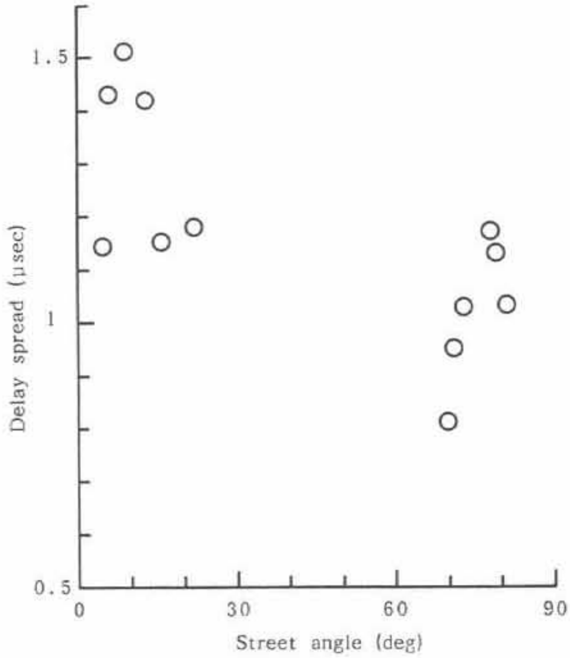

Fig.5 Variation of measured delay spread with street angle.

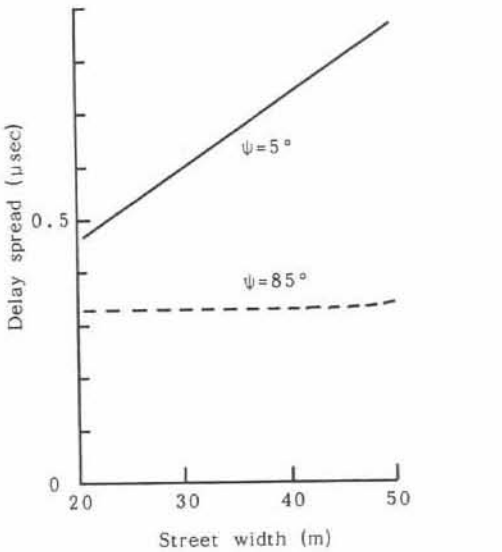

Fig.6 Variation of estimated delay spread with street width.

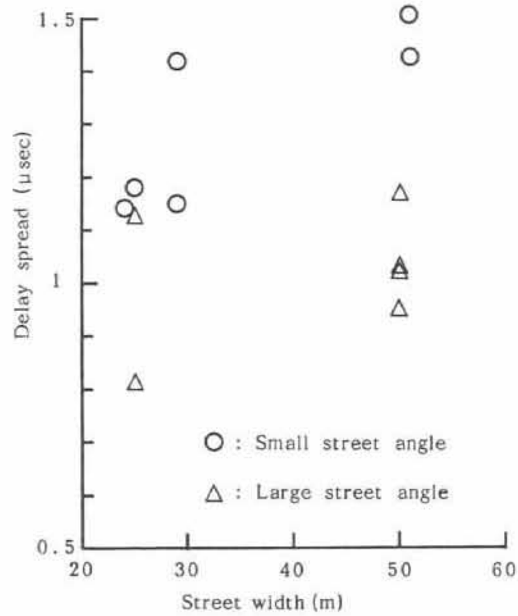

Fig.7 Variation of measured delay spread with street width.