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LINE-OF-SIGHT MICROWAVE RADIO PROPAGATION CHARACTERISTICS IN GHANA

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1. Introduction

It is said that the radio propagation data in tropical regions of the world are lacking, and it is necessary to study the radio propagation characteristics in order to design effective and economical radio-relay system.

The line-of-sight microwave propagation test were started in January 1990 in Ghana at tropical region of west Africa.

This paper describes the results of measuring the fading occurrence factor Pr and the effect of a large spacing antenna diversity to study the mechanism of the severe attenuation type fading detected in Ghana.

2. Outline of the propagation test

The propagation test was carried out on three paths along the seashore in the south part of Ghana using FM microwave radio-relay-link. The route map of the test paths is shown in Fig. 1. The parameters of these test paths are shown in Table 1. The short distance path is adopted in conjunction with the longer paths to study the effect of distance on the fading occurrence factor.

With respect to terrain conditions, all test paths are located in flat savannas. The path profiles are shown in Fig. 2. Two 1.2mϕ sub-antennas were installed 2.5m above the ground (33m above sea level) at the Sege radio-relay station.

The paths to the sub-antenna (slant path) are obstructed by the surface of the earth during the steady-state condition in which the coefficient of the effective radius of the earth k is about 5/3 in the southern part of Ghana. However, when a duct is generated, the value of k becomes larger than usual and clearance of the slant paths become large as shown in Fig.2. Thermo-hygrometer was also installed at Sege radio-relay station.

3. Fading occurrence factor Pr

For large fade depths, the fraction of time P that the fade depth A dB is exceeded in average worst-month is approximately given by the asymptotic equation(1).

$$P = K\,Q\,f^{B} d^{C} 10^{-A/10} = Pr\,10^{-A/10} \tag{1}$$

where :

P : fading probability in true value

KQ : a factor for climate, terrain effects and path variables

f : frequency in GHz, B, C : constant shown in reference (1)

d : path length in km

In Equation (1), Pr is defined as the fading occurrence factor in true value or the equivalent Rayleigh fading occurrence rate (2).

In the propagation test, Pr was measured approximately by counting the number of hours in which fading depth exceeded 30 dB for interference-type fading (Rayleigh fading) and the total time of the period in which fading depth exceeded 30 dB for attenuation-type fading.

The monthly variation in the measured Pr over a two-year period is shown in Fig.3. Most of the worst values of Pr were observed during the Harmattan season, the period from November to February when a dry and dust-laden wind blows from the Sahara desert.

On 26, 27 February 1990, severe attenuation-type fading was observed in the Akatsi-Sege and Tema-Sege hops as shown in Fig.4. As a result of this extreme fading, the value of Pr went up sharply.

The worst values of Pr during the two-year period are shown in Fig.5. Some kinds of estimation curves reported in CCIR (1) are also shown. There is a large difference in the worst values of Pr in 1990 and those in 1991. At present, the average worst-month values of Pr can not be clearly determined for the purposes of introducing the estimation formula of Pr in Ghana. Propagation tests should be continued for several years more to obtain the average worst-month data.

4. Space diversity measurement

It was shown by a ray-tracing method that the formation of a super refractivity layer (duct) causes attenuation type fading (3)(4), and it is expected that the large spacing antenna diversity would be effective in overcoming the attenuation-type fading.

Fig. 6 shows an example of space-diversity data obtained on 5, 6 January 1991, on the Sege-Akatsi hop. In most cases, when the main-signal level was attenuated , a sub-signal level arose even if the sub-signal level was on the low level of around -40 dB due to terrain obstruction.

The cumulative distribution of the space diversity reception signal levels is shown in Fig.7. The space diversity improvement factor I (1) is about one decade in this case and it is confirmed that large spacing antenna diversity is effective in overcoming for attenuation-type fading.

5. Diurnal variation of the number of fading

Table 2 shows an example of diurnal variation of the number of fading. Fading occurred often in the early morning, evening and through the night. Most of all the attenuation type fading were observed during the night and the early morning.

6. Conclusion

Microwave line-of-sight propagation data was obtained in Ghana over a two-years period. A large fading occurrence factor and severe attenuation-type fading were observed. Large spacing antenna diversity was found to be effective in overcoming attenuation-type fading.

Propagation data needs to be collected some years more to obtain the average worst-month data and to introduce the estimation formula of fading occurrence factor Pr in Ghana.

Acknowledgement

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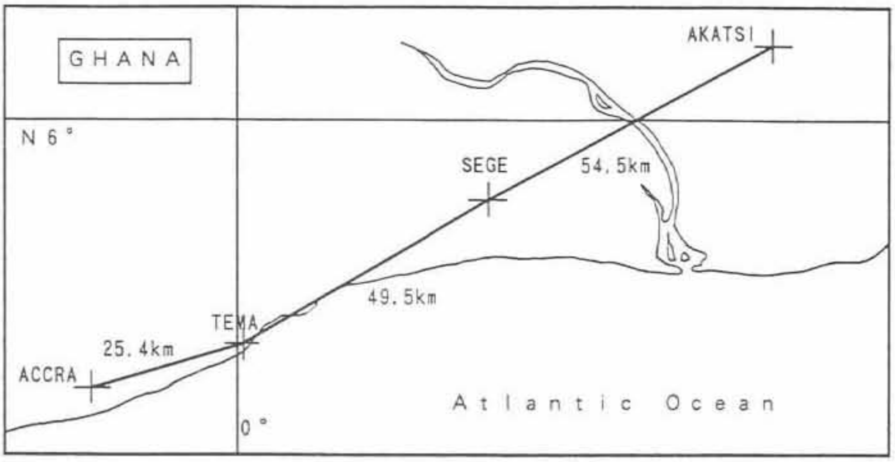

Fig. 1 A MAP OF PROPAGATION TEST PATH

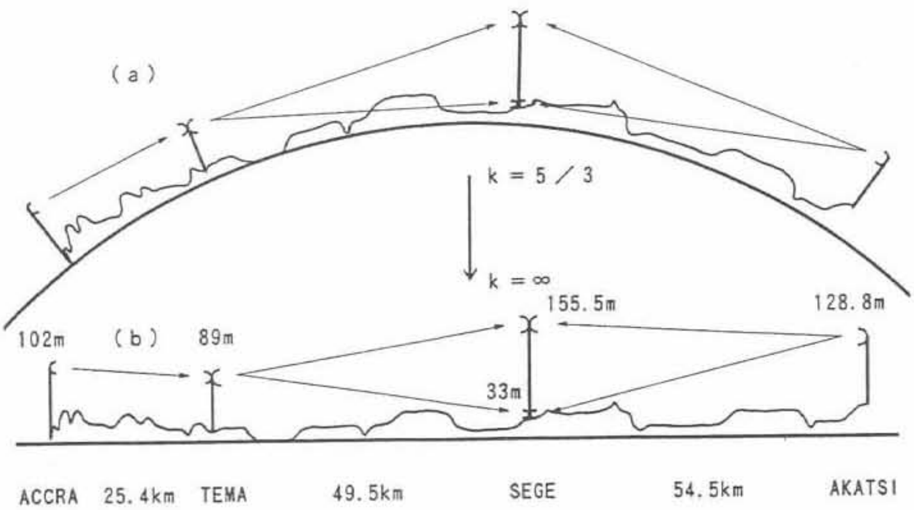

Fig. 2 PROFILES OF PROPAGATION TEST PATH

Table 1 PARAMETERS OF PROPAGATION TEST PATH

Hop	f (GHz)	Distance (km)	Antenna height above sea (m)	Antenna diameter(m)	Path geographic condition
ACCRA ⇒ TEMA	6.8	25.4	102. 89	3.3. 3.3	Coastal region
TEMA ⇒ SEGE	6.46	49.5	89. MAIN 155.5 SUB 33	4.0. 4.0 1.2	Coastal region
AKATSI ⇒ SEGE	6.46	54.5	128.8. MAIN 155.5 SUB 33	4.0. 4.0 1.2	Flat field region

Table 2 DIURNAL VARIATION OF THE NUMBER OF FADING

Time	0–2	2–4	4–6	6–8	8–10	10–12	12–14	14–16	16–18	18–20	20–22	22–24H
	8	10	13	10	5	3	2	1	3	3	3	6
	18		23		8		3		6		9	

(Period: 1∼28 February 1990. AKATSI ⇒ SEGE)

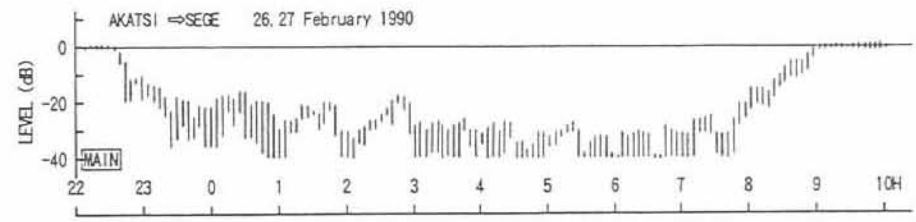

Fig. 4 AN EXAMPLE OF FADING DATA

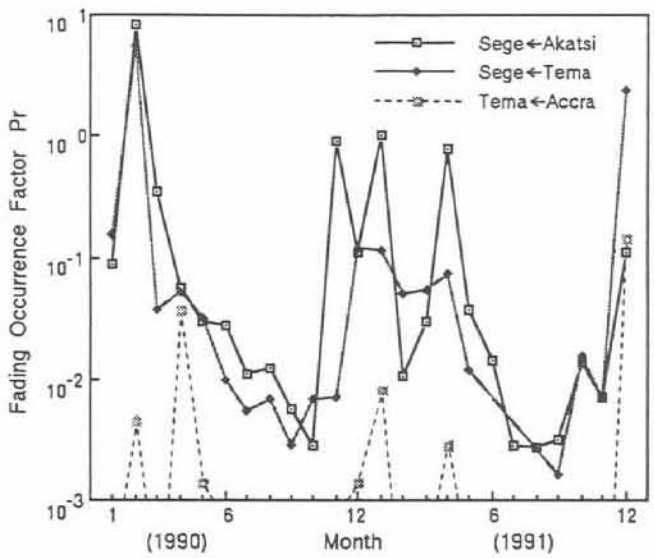

Fig.3 Monthly variation of fading occurrence factor Pr

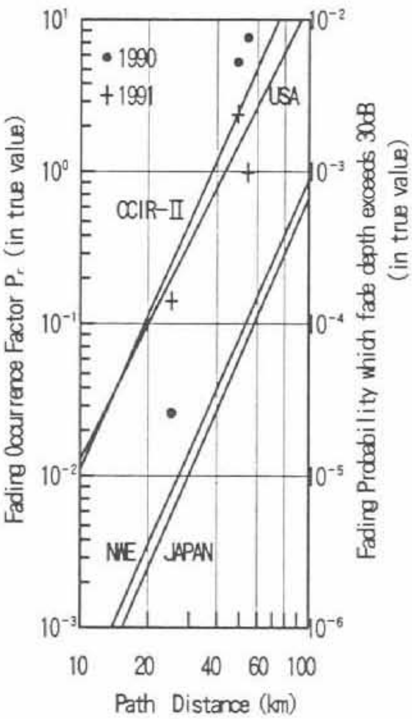

Fig.5 Pr VS. DISTANCE

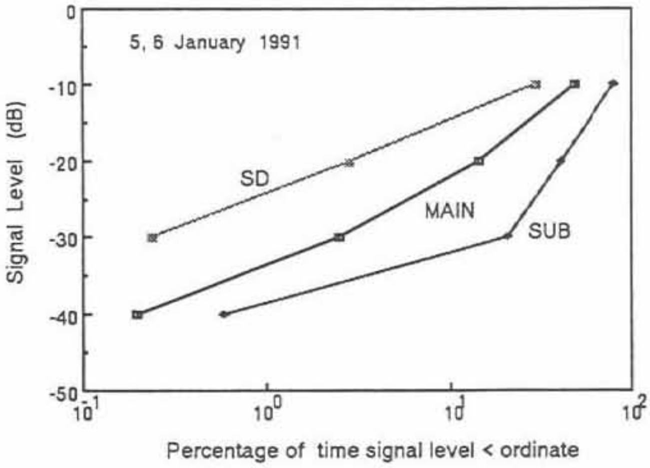

Fig.7 Cumulative distribution of the received signal level by space diversity

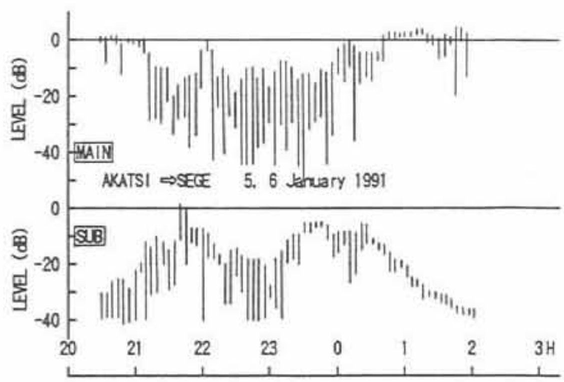

Fig. 6 AN EXAMPLE OF SPACE-DIVERSITY DATA