REDUCTION OF FADINGS DUE TO DUCTS IN LINE-OF-SIGHT LINKS BY PATH INCLINATION

A.C. PEREIRA NETTO
Empresa Brasileira de Telecomunicações
(EMBRATEL)
Av. Pres.Vargas, 1012-Rio de Janeiro-Brasil

N.R.DHEIN
Centro de Estudos em Telecomunicações da Universidade Católica (CETUC)
R.Marquês de S.Vicente,225-Rio de Janeiro-Brasil

ABSTRACT

Propagation tests in line-of-sight microwave links with different path inclinations have been carried out in a particular region of Brazil where development of troposphericducts has been observed. In parallel with these tests, a computer simulation of the performance of those links has been made on the basis of several M profiles measured and of a geometrical optics model. Both theoretical and experimental results have revealed that duct's fadings occurrence may significantly be reduced with an increase in path inclination. Statistics of fadings are also compared with double space diversity.

1. INTRODUCTION

It is known that line-of-sight microwave links are greatly affected by tropospheric ducts. If such a phenomenon rarely occurs, it generally may be ignored. Nevertheless, if the rate of occurrence of those ducts is high, for instance, in tropical and equatorial regions of Brazil, that will it become a serious problem for the telecommunications systems which use the mentioned links [1].

Results of measurements taken in tropical and equatorial regions of Brazil have demonstraded that development of those ducts occurs close to the soil, at night and on locations where absence of winds predominates, whose relief is slightly rough and whose average temperature and relative humity are high, though they show great oscillation in the period of one day. The vertical M profiles present inversions at short height intervals and a great time variability which is, in turn, followed by random variations of reception level at links located in those areas.

There is a experimental evidence that the rate of multipath fadings in line-of-sight radio links decreases with path inclination [2]. In links over rugged terrains without obstruction, multipaths are mainly caused by tropospheric stratifications. Therefore, the following question may be proposed: in extreme cases of stratification of tropospheric layers, that is, with development of ducts whose structures are quite random in time does a greater difference in height between antennas also decrease the occurrence of fadings? The results presented in this work contributes to the understanding of this issue [3].

2. DESCRIPTION OF EXPERIMENTS

Many deep fadings were registered in various hops in the period from December (1982) to May (1983), in the line-of-sight microwave radio trunk (6 GHz band) between the cities of Porto Velho (8.46°S, 63.54°W) and Cuiabá (15.35°S, 56.05°W).

Two adjacent hops of this trunk were the most criticals: Cachoeira de

Samuel-São Pedro and Caritiana-São Pedro. Such links are located in the Amazonian region (state of Rondônia), which has an equatorial climate, a slightly rough relief, forests and weak or absent winds. Figure 1 shows a typical section of the record of variations in the receiver level in one of these links at night.

Measurements of M profiles were taken in that region in a period where strong fadings had occurred. For the measurement of vertical profiles a microwave refractometer has been displaced along a tower at Cachoeira de Samuel. Some of these M profiles are shown in figure 2. They clearly shown the formation of tropospheric ducts during evening hours.

The existing towers have enabled installation of an additional receiving antenna at C. Samuel and Caritiana stations, so as to permit two links with different inclinations at each path. This possibility has resulted in an investigation about the influence of path inclination on the statistics of fadings in line-of-sight overland links caused by ducts whose structures show great time variability. The profiles of those links tested for that purpose are shown in figures 3 and 4.

3. RESULTS

First, computer simulations on path inclination and on the effects of those ducts on the mentioned experimental links have been carried out based on every sample of ducts obtained and an optical model for calculating attenuation. The calculation of the ray attenuation was based on the concepts of divergency and convergency of a beam with the help of ray tracing method [4]. Figure 5 presents the results obtained where may be observed a significant improvement in the performance of one paths when the difference between the heights of the transmitting and receiving antennas increase (figure 3).

An experimental trial has been carried out so as to record reception level variations along the time in each links. Through the analysis of these records, correspondent time fading distributions have been obtained. In addition, the rate of fadings for a double space diversity system has also been obtained taking into consideration the simultaneous reception obtained from the two receiving antennas of each path. Figures 6 and 7 present the distributions for the two inclinations and for the space diversity at each path during the worst month. Statistics relative to the total period of measurements are shown in figure 8.

4. CONCLUSIONS

One of the main characteristics of the ducts observed in equatorial and tropical regions of Brazil, besides their low altitude, is the great variability of their structure with the time. This strongly random feature makes the difference between the altitude of the transmitting and receiving antennas become an important factor concerning intensity of the effects of those ducts, as much as that a significant decrease in fadings occurrence may be felt as path inclination increases. A greater inclination plus space diversity may result in considerable improvements.

REFERENCES

[1] DHEIN,N.R., "Measurements of Radio Refractive Index Profiles at Tropical and Equatorial Regions and their Influence on Line-of-sight Microwave Links", Proc. URSI Comission F Symposium, Louvain, Belgium, June 1983.

[2] SASAKI,O. and TODASCHI,A., "Multipath Delay Characteristics on Line-of-Sight Microwave Radio Links", IEEE Tran. on Communications, Vol.COM-27, Dec.1979.

[3] CCIR: Draft Revision of Report 784, May 1984.

[4] IKEGAMI,F.,"Influence of an Atmospheric Duct on Microwave Fading", IRE Trans. Ant. and Prop. AP-7 (1959).

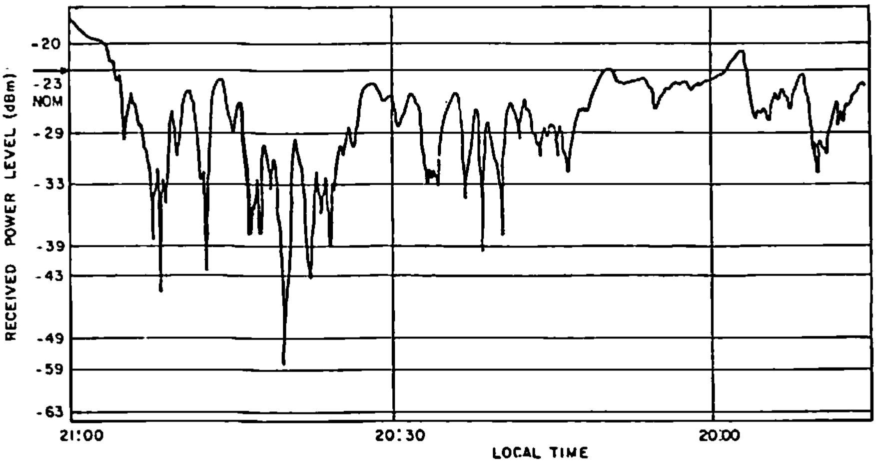

FIG. I — EXAMPLES OF FADINGS IN S. PEDRO - C. SAMUEL LINK

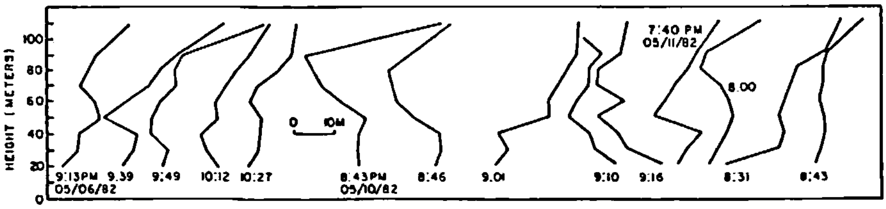

FIG. 2 - EXAMPLES OF VERTICAL M PROFILES MEASUREDS AT CACHOEIRA DE SAMUEL

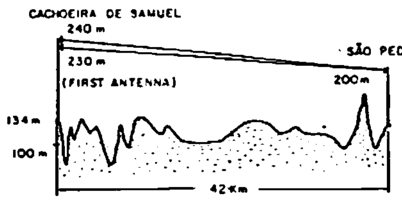

FIG. 3 - SÃO PEDRO - CACHOEIRA DE SAMUEL FIELD TRIAL PATH PROFILE.

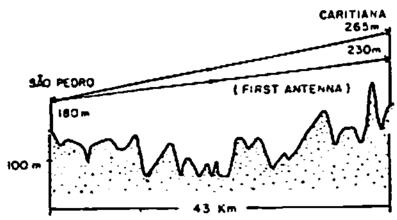

FIG. 4 - SÃO PEDRO - CARITIANA FIELD TRIAL PATH PROFILE.

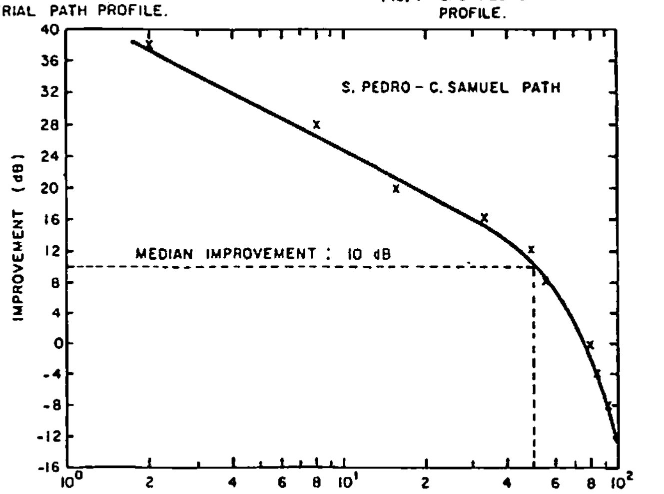

FIG. 5 - COMPUTER SIMULATION RESULTS

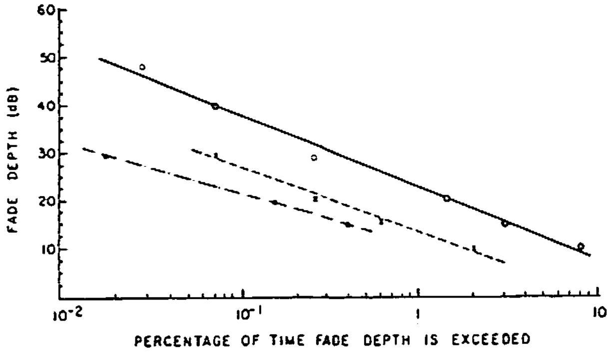

FIG 6 – FADE DISTRIBUITIONS FOR TWO PATH INCLINATIONS AND SPACE DIVERSITY DURING WORST MONTH (APRIL 83) IN THE HOP SÃO PEDRO/CACHOEIRA DE SAMUEL

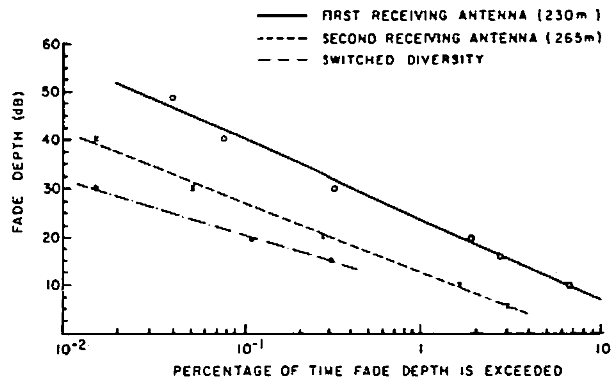

FIG. 7 – FADE DISTRIBUITIONS FOR TWO PATH INCLINATIONS AND SPACE DIVERSITY DURING WORST MONTH (JANUARY 83) IN THE HOP SÃO PEDRO/CARITIANA

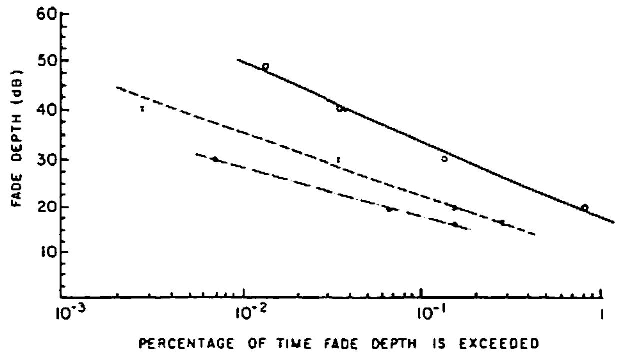

FIG. 8 – FADE DISTRIBUITIONS FOR TWO PATH INCLINATIONS AND SPACE DIVERSITY TO THE TOTAL PERIOD OF MEASUREMENTS (FIVE MONTHS) IN THE HOP S. PEDRO/CACHOEIRA DE SAMUEL.