VHF RADIOWAVE PROPAGATION MEASUREMENTS IN NIGERIA

[+] O. A. Aboaba and [++] G. O. Ajayi
Department of Electronic and Electrical Engineering,
Obafemi Awolowo University,
Ile-Ife, Nigeria.
[+] Email: oaboaba@oauife.edu.ng
[++] Email: gajayi@oauife.edu.ng

Abstract

This report describes the results of over one year of radiowave propagation measurements carried out at Ile-Ife, Nigeria. The signal level of a radio transmitter located in Lagos was received in Ile-Ife, both in the southwestern part of Nigeria. The frequency band was VHF and the path length approximately 200km.

Analysis has been made of the field strength behaviour, together with a critical investigation of the prevailing meteorology during the period of this measurement. The results show that the measured values of field strength were significantly high in the night and morning hours for large percentage of the measurement period. These high values of field strength, which approach the free space level on certain occasions, (and sometimes even exceed it), are due to the extreme refractivity gradients which are frequently present in the region of West Africa. This result could have serious consequences for planning of VHF radio broadcasting services in the southwestern part of Nigeria since it is likely that the incidence of interfering signals will be high.

1.0 Introduction

A reliable operation of ground-based communication systems for radiocommunication purposes largely depends on a good knowledge of the propagation characteristics of the area of interest. Such information is required, not only to ensure that an adequate service will be provided, but also to help assess the potential for interference between stations working in the same band or, in a worse case, stations sharing the same frequency.

During the last century, the earth's atmosphere with a boundary formed by the earth's surface has been the subject of many investigations as a radiowave propagation medium[5]. These investigations have, in the case of carrier waves of frequencies less than 50MHz, provided a considerable knowledge of the propagation properties of the atmosphere and also of the effects of the known inhomogeneities or boundaries, such as the ionospheric regions and the earth's surface. Such a knowledge, which relies very largely on a vast store of accumulated statistical information, allows fairly accurate predictions of the propagation characteristics of low- and medium- frequency systems to be made in practice. However, where carrier frequencies greater than 50MHz are employed, investigation and practice have shown that inhomogeneities due to the ionospheric regions are of little or no consequence and that wave propagation may be assumed to be restricted to that region of the earth's atmosphere known as the troposphere. The troposphere being the nearest region of the atmosphere to earth, experiences conditions of continual motion [1]. The physical properties of this complex gaseous region are known to have considerable influence on a high-frequency wave propagated. The extent of the influence does not, however, appear to be clearly understood.

As a result of the lack of knowledge, the art and science of panning a tropospheric communication link is extremely complicated. In the planning of any communication link, field surveys are necessary in order to sample and establish the true practical propagation characteristics obtainable over a particular path at a given instance. For low- or medium frequency transmission where ionospheric paths are considered, surveys need only be of short duration in a large number of instances, since they are supplemented by a vast amount of statistical information, which is already available. For VHF transmission propagated over tropospheric paths, relatively long-duration field surveys are necessary

because of the present lack of knowledge of the more essential properties of the propagation medium combined with the lack of relevant statistical information.

2.0 Experiment

2.1General

Ile-Ife lies in the southwestern part of Nigeria between latitudes 7^0N and $7^0 35^1$N, longitudes $4^0 20^1$E and $4^0 45^1$E, covering an area of 1846km^2[4]. Its climate is tropical i.e. hot and humid with two main seasons: rainy season (approximately April to October); dry season (approximately November to March) dominated by hot, dry harmattan winds. The propagation link is essentially a land path.

2.2 VHF Propagation Measurement Experiment

The aim of the experiment was to carry out continuous measurements of the field strength resulting from a radio transmitter in the VHF band over a path length of about 200km. Table1 gives details of the experiment. The measurement system is made up of a receiving antenna, a radio receiver, a data logger and a personal computer. The receiving system was used to sample every minute, the signal level of the VHF radio transmitter over a 24hours period daily. The measurement commenced in September 1998 and was carried out continuously for more than one year. However, there was a breakdown of the receiver in December 1998 and hence no data was recorded during this month.

The computer controls the acquisition of data by using RS232 commands sent to the radio receiver and data logger respectively. The total gain of the receiving system was estimated to be 22.0dB. The measured signal level was downloaded on floppy discs as values of voltage, and these were subsequently converted to values of field strength using equation 1.0. Using information available from table 1.0 and equation 2.0, the free space field strength at Ile-Ife was estimated to be 73.52dBμV/m[2]. Taking into account the possibility of small variations in the transmitted power from time to time, and also in the characteristics of the receiving equipment, it is estimated that the overall error in the field strength values is no greater than ±2dB.

2.3 **Results**

Each signal was sampled at approximately one-minute intervals. The cumulative totals for signal level were then produced every hour. These hourly cumulative results were then combined to produce daily, weekly and monthly totals. The twelve-month total of received field strength is shown in Fig.1.0

Fig.2.0 shows diurnal variation of the received field strength which exceeded the free space value during the late night and early morning hours. This diurnal variation is caused by rapid convection cooling of the hot ground surface after sunset leading to duct formation in the atmosphere above. Whilst this is a well-documented propagation mechanism, interference prediction methods, which are used in broadcasting, do not model this effect very well.

The hourly variation shown in fig. 3.0 describes slow variation of the received field strength.

$$\text{Field Strength (dB}\mu\text{V/m)} = \text{Signal Level (dB}\mu\text{V)} - 1.307\text{dB} - 22.0\text{dB} \qquad (1.0)$$

$$E = \frac{\sqrt{30 P_t}}{r} \qquad (2.0)$$

Table 1.0 Parameters of the VHF propagation measurement

Frequency	100.50MHz
Tx. Antenna Height	274.32m
Rx. Antenna Height	10 m
Tx. E.r.p	30kw
Path Distance	200km

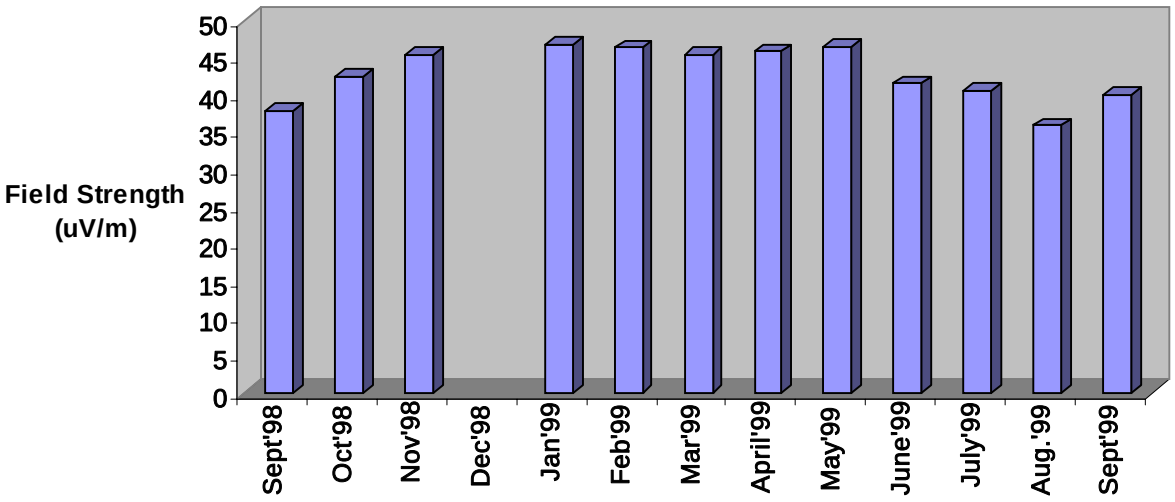

Fig.1.0 Monthly totals of received field strength

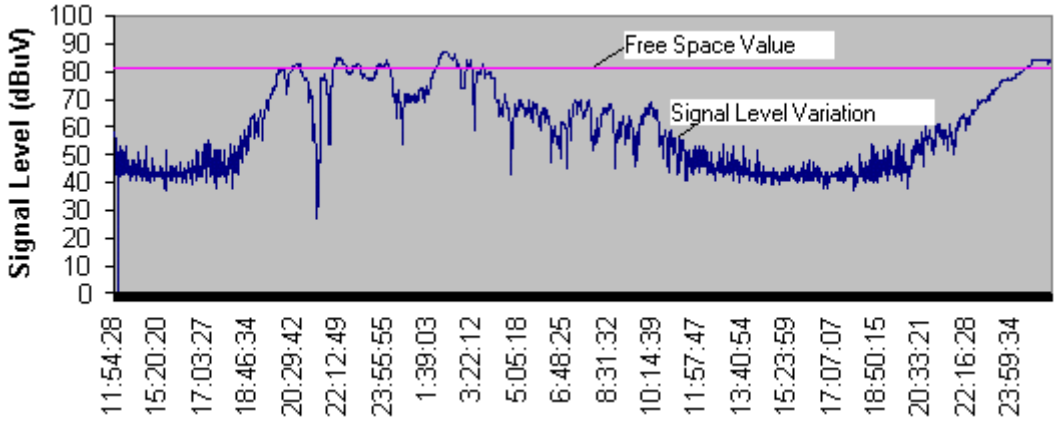

Fig.2.0 Diurnal Signal Level Variation, February 8-10th 1999.

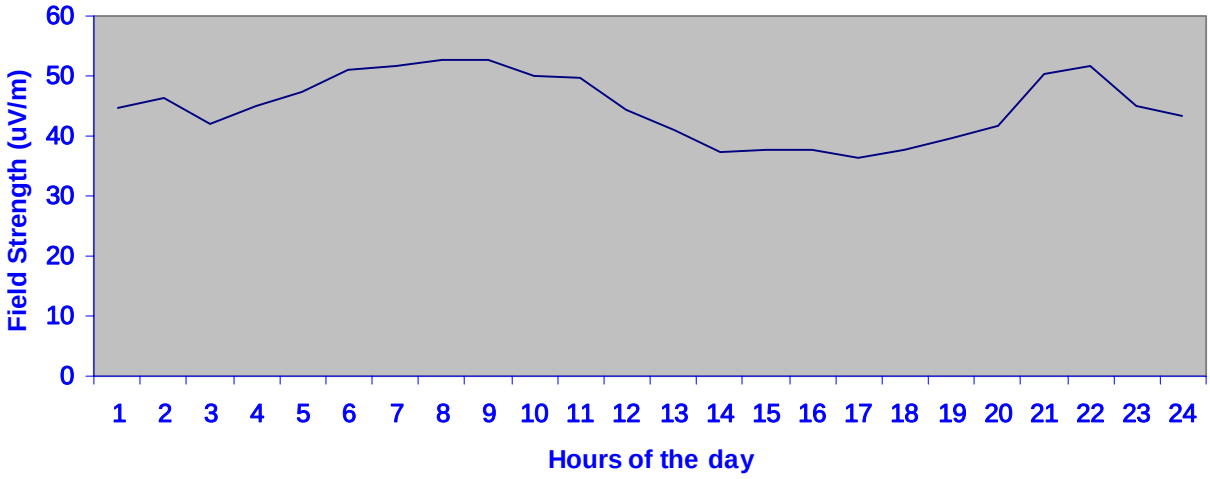

Fig.3.0 Hourly variation of received field strength, October 24th 1998.

3.0 Conclusion

The data obtained from the experiment clearly indicates that higher values of field strength were obtained than would have been predicted by well-known, established prediction methods[3]. This result could have serious consequences for planning of VHF radio broadcasting in the southwestern part of Nigeria since it is likely that the incidence of interfering signals, associated with small time percentages typically from 10 to 1%, will be underestimated by using the existing prediction methods. This indicates a high occurrence of transhorizon in this area.

The data acquired from the propagation measurement will be submitted to the ITU-R database as a contribution towards frequency spectrum planning and management in a tropical climate.

4.0 References

[1] W.G. Burrows, "VHF radiowave propagation in the troposphere", International Textbook Company Ltd, Intertext House, Parkgate Road, London. pp1-8, 1968.

[2] J.Griffiths, "Radiowave propagation and antennas; an introduction", Prentice-Hall International, pp5-22, 1987.

[3] Recommendation P.370-7, "VHF and UHF propagation curves for the frequency range from 30MHz to 1000MHz", pp1-8, 1995.

[4] O.A. Aboaba, "Experimental Studies in the VHF/UHF Frequencies in a Tropical Climate", URSI '99, XXVIth General Assembly, Toronto, Canada. p375, 1999.

[5] O.A. Aboaba, "Experimental Studies of Long Distance Propagation in the Troposphere", AP2000, Millennium Conference on Antennas and Propagation, Davos, Switzerland. 2000.