DETERMINATION OF WIRELESS (2.45GHz) ATTENUATION LOSS THROUGH SOME NIGERIAN TREES AND FOLIAGES

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ABSTRACT

The dependence of vegetation attenuation on some Nigerian trees and foliages was investigated. Measurements were conducted on isolated single tree and set of trees aligned in series with varying degrees of foliation at wireless frequencies and compared with the calculated result. The trees considered are Gmelina, Palm tree, Plantain Plantation, Tick and Umbrella tree. The measurement was obtained using free loss method of measurement using a Wireless Router (TP-LINK) and a mobile wireless signal analyzer (Keuwlsoft Wi-Fi) by erecting it pointing towards the canopy for greater illumination. The results of this investigation revealed that as the experimental trees grow more leaves, canopy gap fraction becomes smaller causing high radiation interception and leading to high signal attenuation loss and this was practically more in Gmelina trees followed by the Umbrella and this continues down the trend due to the size of the leaves and the shadow capacity forming. The result is a clear evidence of the significance effect of foliage (leaves) and tree in the estimation of vegetation attenuation.

INTRODUCTION

The effect of vegetation along wireless radio signal propagation path can cause significant attenuation of signal waves and result in much reduction of the communication coverage range of the radio equipment Savage, *et. al.*, (2003). This attenuation is as a result of scattering, absorption, reflection and diffraction suffered by the waves. A quantitative knowledge of excess propagation loss suffered by radio wave due to presence of foliage is essential for planning a communication link in any vegetated channel. This has stimulated a lot of experimental work by researchers in the field Nathan, (2009). Generally, the foliage induced excess loss will be a function of the propagating frequency and vegetation depth as in the relation where, and are variables in which their values can be obtained through measurements which indicate the frequency and distance dependences of vegetation-induced excess loss in the parametric equation. All existing empirical loss prediction models are in agreement with Equation 1.0 below. However, our recent findings Hardwell, (2005), revealed that the degree of vegetation foliation is another key factor that will determine the amount of excess vegetation loss.

In an effort to substantiate this, Robert, (2003) measured propagation losses on two foliated isolated trees (Plane and Gingko) at 29.5 GHz. He recorded 18 dB and 6.3 dB respectively on the trees. The author went further to populate canopy elements by adding more branches to the trees, aimed at increasing leaf density and canopy thickness. His observation revealed increase in measured attenuation. Savage, *et. al.* (2003) carried out series of measurement campaigns on selected vegetation at 1.3, 2.0 and 11.6 GHz. Their results show that leaf density, leaf state and measurement geometry are other important factors influencing signal attenuation in vegetation. In a similar manner, Rogers, *et. al.*, (2002) carried out a study in UK on the effects of millimeter wavelengths radio wave propagating through vegetation. Reports of their study showed that vegetation attenuation is dependent on certain number of factors e.g. leaf state, leaf density, vegetation type etc. Meng, *et.al,* (2009) carried out to study the effects of forest on the propagation of radio links.

Of all of the signal propagation effects typically evaluated for communications links operating in the radio frequency wave regime, signal attenuation due to foliage is probably the most difficult to accurately quantify. The wide diversity in the types and density of foliage makes the estimate of attenuation highly variable. Most studies performed to date to quantify the impact of signal attenuation due to propagation through foliage have been concerned with horizontal propagation paths (i.e., parallel to the ground). Typical examples of such studies are found in Mosesen, (2002), which treat the frequency region below 1250MHz. In this region, the leaves are small compared to the wavelength and the forest is treated as a homogeneous layer above the Earth. The homogeneity assumption is not acceptable in the millimeter wave regime, where the leaves and the spaces between the leaves are large compared with the signal wavelength. As one might imagine, the inconsistency in characterizing foliage from one study to another has led to a great deal of inconsistency in developing empirical models to characterize the limited amount of measured data. For example Adegoke, *et, al.,* (2015), state that the one-way attenuation resulting from leaf-bearing trees for systems operating in the .1 to 3 GHz frequency range could be characterized by the equation:

$$A = 0.2 f^{0.3} \cdot d^{0.6} \qquad 1$$

Where A = Attenuation, f is frequency and d the depth distance in km

Where f is the operating frequency in GHz and = 0.75. LaGrone, (1961) slightly adjusted the constant and exponent in equation 2.

Perhaps the most pertinent data to this discussion has been generated by Currie, *et al.*, (1976) at the Georgia Technology Research Institute (GTRI) at discrete frequencies up to 90 GHz. The measurements were performed by radar techniques, using a corner reflector target embedded in the foliage and measuring two-way attenuation. Al-Nuaimi and Stephen, (1998) developed the following expression for the attenuation due to foliage as a function of operating frequency, f, and the foliage thickness, t:

$$A(dBm) = 1.33 f^{0.3} \cdot t^{-0.412} \qquad 2$$

t = foliage thickness, f= frequency, A= Attenuation in dBm

The thickness dependence phenomenon is also reported by Nathan, (2009); albeit with different constants and power coefficients. Equations 1.0 and 2.0 were used to generate the foliage attenuation data shown in the graphs as a function of operating frequency through a foliage thickness of one meter. As shown, the various analytical expressions yield fairly similar results, typically within 1 dB of each other. Also shown in Table 1 are the measured experimental data from the GTRI experiments reported for operating frequencies of 16.2GHz and 35 GHz. These data are within several tenths of a dB from the data generated from the empirically derived expression in Tables 2 and 3. In this study, the dependence of vegetation attenuation on some Nigerian trees and foliages was investigated

MATERIALS AND METHOD

Materials used in this work are: Wireless router, Signal analyzer, Micrometer Screw gauge, Tape, Retort stand etc. A wireless signal was propagated/transmitted privately named: PHYSICS ELECTRONIC RESEARCH GROUP and propagated using a router and distance were measured, the materials employed in this work were:

- Tp-Link Router (Receiver)
- Wi-Fi signal analyzer (Transmitter)
- Uninterruptible Power Supply (UPS)

The experimental set up for measuring the received power level where foliage obstructs the Tp-Link and Wi-Fi signal analyzer during signal transmission. The distance between the transmitter and receiver were varied between 5 m, 10 m and 15 m respectively. At the transmitting section, the Tp-Link with directional antenna of transmitting power 12 dB is mounted at the top of 7m high mast. Along the transmission path lays foliage of different trees Gmelina, palm tree, plantain plantation, Cashew and Umbrella tree. The distance between transmitter and receiver were varied for each zone. The receiving section consisted of a Wi-Fi signal analyzer with an in-built antenna that was synchronized to a laptop for data logging. Both Transmitter and Receiver were powered using uninterruptible power supply (UPS) to avoid power disruption which may eventually result in data loss.

Wi-Fi Analyzer

Keuwlsoft signal meter is a mobile application meter that measures the wireless signal loss at any range with the IP of 192.189.11. This was used in taking the measurement for the attenuation through the material at every distance away from the obstruction.

Obstruction loss was calculated using equation 0.3 which gives the attenuation loss at free space in Table 1.

Table 1: Free loss attenuation at 5, 10 and 15m distance

Free Space Loss	-58dBm	-61 dBm	-71 dBm

Table 2: Table 1: Calculated trees attenuation loss in dBm at 5, 10 and 15m distance

S/N	Types of Tree	5m	10m	15m
1	Gmelina	4 dBm	5 dBm	3 dBm
2	Palm tree	11 dBm	13 dBm	4 dBm
3	Cashew	2 dBm	3 dBm	5 dBm
4	Plantain	11 dBm	13 dBm	4 dBm
5	Umbrella Tree	2 dBm	11 dBm	2 dBm

Table 3: Attenuation loss through leaves, trunks and foliages

S/N	Tree Type	Trunk Cross	Height (m)	Leaf Thickness (μm)	Distance Apart	5m	10m	15m
1	Gmelina	0.4 - 0.9	2.13	0.10	7	-62	-66	-74
2	Palm tree	2.2 -2.23	2.13	0.21	6	-69	-74	-75
3	Cashew	0.20 - 0.26	2.0	0.12	5	-60	-64	-76
4	Plantain	0.20 - 0.31	1.5					
5	Umbrella Tree	3.0 - 3.8	2.3		7	-60	-72	-73

RESULTS AND DISCUSSION

Leaves are modeled as thin lossy dielectric disks and branches as finite lossy dielectric cylinders. From the standpoint of wave signal propagation, trunks, leaves, and branches of individual tree scatter or absorb electromagnetic waves. Propagation measurements through vegetation at wireless frequency (2.45GHz) were carried out in Domita Farm and in University of Uyo perm site on various trees and foliage (Cashew tree, Umbrella tree, Palm tree, Gmerlina tree and Plantain). The effects of vegetation on wireless signal propagation in rural areas have been studied by Kin *et.al*, (2011) and it shows that attenuation of signal is more paramount because of much vegetation. The signal attenuation researched on various trees are as follows; Cashew Tree recorded 2dB at 5m, 3dB at 10m and 5dB at 15m, Umbrella Tree recorded 2dB at 5m, 11dB at 10m and 2dB at 15m, Plantain recorded 11dB at 5m, 13dB at 10m and 4dB at 15m, Palm Oil Tree recorded 11dB at 5m, 13dB at 10m and 4dB at 15m, while Gmerlina had 4dB at 5m, 5dB at 10m, and 3dB at 15m.

CONCLUSION AND RECOMMENDATION

This work has revealed the effects of the obstruction of trees and foliage on the wireless signal network through PHY ELECT. RES.GROUP UNIUYO signal. The study has shown that one of the problems that hinder efficient performance of the wireless signal network is the presence of trees and foliages (but there are other factors that hinder). This resulted in poor signal reception, missing of data packets, delay in uploading and downloading of data, and fluctuation of signals. Measured data from these experiments can then be used to evaluate current prediction models and to propose a loss prediction model which will be generic in application.

REFERENCES

Adegoke, A.S, Balogun, W.A and Phillips, D.A (2015). Broadband wireless access in Vegetated Channel. *International Journal of Innovative Research in Engineering & Science,* 4(4): 11 - 16

Al-Nuaimi, M. O. and R. B. L. Stephens, (1998). Measurements and prediction model optimization for signal attenuation in vegetation media at centimeter wave frequencies. *IEE Proc. Micro. Ant. Prop.*, 145 (3): 201 – 206.

Currie, N.C., Dyer, R. and Martin, J. (1976). Millimeter Foliage Penetration Measurements. *Abstract of the IEEE AP-Society Symposium,* pp 575 – 577.

Hardwell, K. M. (2005). *A Comparison 802.11 Wireless Transmitter Localization Techniques.* Oklahoma University. ITU, 2001. Attenuation in Vegetation," International Telecommunication Union, R P.833-3, Geneva.

Johnson, R. A. and F. Showering, (1985). *A Transport Theory of Millimeter Wave Propagation In Woods and Forests.* Research and development technical report , US Army Communications. CECOM Report.

Kin, L. C., Saul, A.T. and Thomas, K. (2011). *Foliage Attenuation over Mixed Terrains in Rural Area for Broadband Wireless Access at 3.5GHz. IEEE Transaction on Antennas*, 59(7): 2698 - 2706

LaGrone, A. H. and Chapman, C. W. (1961). Some Propagation Characteristics of high UHF Signals in the immediate vicinity of trees. *IRE Transactions Antennas Propagation*, 9: 957-963.

Meng Y. S., Lee, Y. H., Ng, B. C. (2009). Study of propagation loss prediction in forest environment. *Progress in Electromagnetic Research B*, 17: 117- 133.

Mosesen, K.. (2002). *Vegetation Attenuation of Microwave: Measurements and Model Evaluation.* Tech. Rep. FFI/RAPPORT-2002/04143, Norwegian Defense Research Establishment.

Nathan, .D. (2009). Campus Wide Network for University of Nigeria Nsukka, Nsukka Campus. *Nigerian Journal of Technology,* 29: 10-15

Robert, K. C. (2003). *Propagation Handbook for Wireless Communication System Design.* CRC Press LLC, Boca Raton London New York Washington, D.C. ISBN 9780849308208

Rogers , N.C., Seville, J. R., Ndzi, R. F. S., Caldeirinha, A. K. and Austin, J. (2002). *A Generic Model Of 1-60ghz Radio Propagation through Vegetation*. Final report. QinetiQ, 2002.

Savage, N., Ndzi, D. L.. Seville, A. , Vilar, E. and Austin, J. (2003). Radio wave propagation through Vegetation: Factors influencing signal attenuation. *Radio Science*, 38 (5): 1088.