© 2015 IJSRSET | Volume 1 | Issue 4 | Print ISSN : 2395-1990 | Online ISSN : 2394-4099
Themed Section: Science

Investigation into Path Loss Propagation at UHF Band in Low Latitude Region

Aremu O. A[*1], Ajao O. S[2], Falade T. J[3] Oyinkanola L. O. A[4]
[1,3,4] Department of Physics, The Polytechnic, Ibadan P.M.B 22, U.I Post office, Ibadan. Oyo State, Nigeria
[2] SLT Department, The Oke Ogun Polytechnic, Saki PMB 021, Saki, Oyo State, Nigeria

ABSTRACT

Knowledge of propagation characteristics in the mobile channel is important to the design of a cellular system. It is a major component in the analysis and design of the link budget of a Telecommunication system. This paper deals with the outdoor path loss bahaviour. The study has been conducted in The Polytechnic, Ibadan at GSM frequency 900MHz so as to fit a suitable propagation model within the campus and environs. The experimental data collected from measurements were compared with Cost 231 Hata model, Erickson model and free space models. The results are in good agreement with Cost 231 Hata model. The accuracy of the results is estimated by determine the mean square error between the measured and estimated path loss of the empirical model. The mean square errors, μ at different height were 2.04, 2.71, 2.90, 1.46, and 1.61dBm. The results are in good agreement with the acceptable international range $1 \leq \mu \leq 15$dBm (Wu and Yuan, 1998).
Key words: Path Loss Models, Mean Square Error, GSM Frequency, Cost 231Hata Model, Erickson Model

I. INTRODUCTION

The path loss propagation models have been an active area of research in recent years. Path loss arises when an electromagnetic wave propagates through space from transmitter to receiver. Signal power is reduced due to path distance, reflection, diffraction, scattering, free-space loss, and absorption by the objects of environment [1].Path loss is also influenced by the different environment (rural, suburban and urban). Variation of transmitter and receiver height also produces path loss [2]. A fundamental element of wireless communication system planning is predicting the signal strength at same location that results from a transmitter at some other location over the years, a wide variety of approaches have been developed to predict coverage using what are known as propagation models. Propagation modelling is an effort to predict what happens to signals en route from the transmitter to the receiver. Obviously, the signal gets weaker with increase in distance.

Prediction and estimation of path loss is an important and significant element of system design in any communication system. A propagation model is also called a "path-loss calculation". The best propagation model for a particular study depends on the type of type of communication system area where it will be used.

II. METHODS AND MATERIAL

PROPAGATION PATH LOSS MODELS

A reliable propagation model is one which calculates the path loss with small standard deviation and this will help to optimize the coverage area, Transmitter power and eliminates undesirable phenomenon, (e.g. interference, noise), etc. of other Radio transmissions. This will equally help network engineers and planners to optimize the coverage area and to determine the correct transmitter power to be used for such an area.

2.1 Free space model (FSPL)

Free space model (FSPL) emphasizes on how much strength of signal transmission between transmitter and receiver lost. This can be determine by [3,4]

PL_{FSPL} $32.48\ 20log10(d) + 20log(f)$ (1)

Where f is the frequency in MHz, d is the distance between transmitter and receiver in metre and p is the power loss in *dBm.*

2.2 Ericsson model

Ericsson model developed software to predict the path loss. The path loss according to this model is given [3], [5], [6]

$$PL = a_0 + a_1.log(d) + a2\ log(h_t) + a3.log(h_t).log(d) - 3.3(\log(11.78h_r))^2) + g(f) \quad (2)$$

Where: $g(f)$ is defined as:

$$g(f) = 44.51log(f) - 4.79\ (log(f)^2) \quad (3)$$

f = frequency in MHz

ht = transmitter height (m)

hr = receiver height (m)

2.3 Okumura model

Okumura model is an empirical model based on extension drive test measurements within the range of 150 to 1920MHz and further extrapolated up to 3000MHZ. He developed a set of curves which gives the median attenuation relative to free space (AMU) in an urban area. The path loss prediction according to Okumura is given by [3,7]

$$L_{50}\ (dB) = LF + Amu(fd) - G(h_b) - G(h_m) - G(Area) \quad (4)$$

Where L_{50} (dB) = median value (i.e. 50^{th} percentile) of path loss propagation

LF = free space propagation

$$G(h_b) = 20log_{\ 10} \quad 1000m > h_b > 30m \quad (5)$$

$$G(h_m)10log_{\ 10}\left(\frac{h_m}{3}\right) \quad h_m \leq 3m \quad (6)$$

$$G(h_m)20log_{\ 10}\left(\frac{h_m}{3}\right) \quad 10\ \leq h_m \leq 3m \quad (7)$$

2.4 COST-231 Hata Model

COST stands for European Co-operative for Scientific and Technical Research. Cost 231 Hata model is widely used for predicting path loss is mobile wireless systems. It is an extension of the Okumura – Hata model. The COST 231 Hata model is designed to be used in the frequency range of 500MHz to 2000MHz. It has correction for urban, suburban, and rural (flat) environments. Because of its simplicity and correction factors, it is widely used for path loss predictions at these frequency bands COST (1999), Hata (1981), Okumura (1968).

The path loss in urban area is given by

$$Pl\ (dB) = [46.33\ 33.9\ log\ (f)] - [13.82\ log\ (hb)] - a(hm)\ [44.9 - 6.55\ log\ (hb)]\ log\ (d) \quad (8)$$

Where:

$a\ (hm)\ 1.1\ log\ (f) - 0.7hm - 1.56log\ (f)\ 0.8$ (9)

The path loss for highway calculations is similar to Okumura-Hata models.

hb is the height of base antenna station; hm is the height of mobile antenna in meters

$a\ (h) = correction\ factor\ in\ dB$

3.0 Experiment Campaign and Methodology

The testing location was based at the faculty of Engineering building, The Polytechnic Ibadan. This building contains three floors (with basement), consisting of a concrete foundation, concrete wall supports, concrete slab floors and walls contain power and cable lines. Due to its structural made up, the building serves as a good representation testing environment for connection monitoring applications. The measurements were carried out in the month of September, October and November 2014, under no wind and no rain. The daily ambient temperature ranges between 28^oC to 33^oC.

The measurement setup consists of the following: An Agilent 895BD signal generator and vertically polarized Omni directional antenna –AX-79C which has typical gain of 2.3dB. The receiver used is HP8547E spectrum analyser for the measurement of signal strength at 900MHz. The received signal passes through the same vertically polarized antenna to spectrum analyser. The measured data was stored in a computer via a GPIB interface through a LABVIEW control program and post-processing of the data were performed offline using MATLAB R2014a.

III. RESULTS AND DISCUSSION

Figures 1 to 5 show the experimental variation of the path loss (dBm) and the models considered against the distance in meter at different heights 2, 4, 6, 8 and 10m. the path loss of all the measured and the models considered shows decreasing trends with respect to receiver height and increasing trend with respect to transmitter distance.

A more accurate comparative analysis for determining the best path loss prediction model for macro environments is the use of the mean square error (MSE) approach. The MSE is the ratio of dispersion of measured path loss values and describes how good the propagation model matches experimental data. It is commonly used verify the accuracy of path loss models. The standard deviation and MSE according to [3] [7] [8] is given by:

$$\sigma = \frac{\sqrt{\Sigma(p_m - p_r)^2}}{N} \tag{10}$$

Where P_m = measured path loss (dB)
P_r = predicted path loss (dB)

$$\mu = \frac{\sigma}{\sqrt{N}} \tag{11}$$

The mean square error analysis shows that Cost 231-Hata prediction model has the smallest MSE for all the heights considered ranges 1.46 to 2.90dBm which is in good agreement with experimental measured values and acceptable international range.

Table 1: Standard deviation and mean square error for Cost-231 Hata model

h(m)	Measured path loss dBm	Cost 231 Hata model	
		σ	μ
2.0	137.40	6.44	2.04
4.0	134.00	8.58	2.71
6.0	133.20	9.17	2.90
8.0	131.00	4.60	1.46
10.0	120.60	5.09	1.61

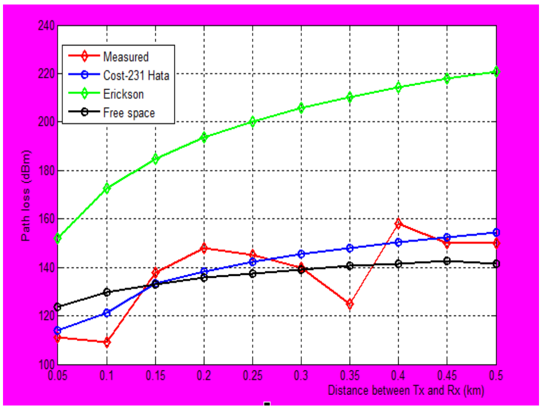

Figure 1 : Path loss against distance at 2m receiver height

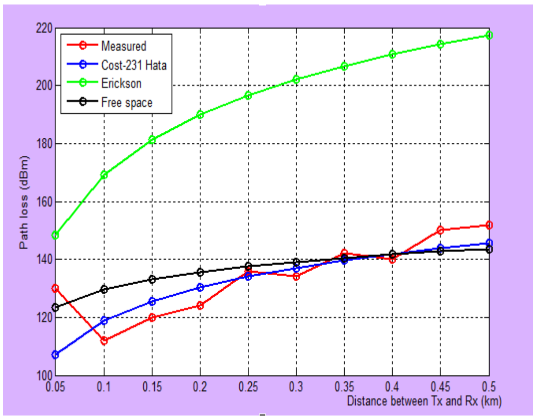

Figure 2 : Path loss against distance at 4m receiver height.

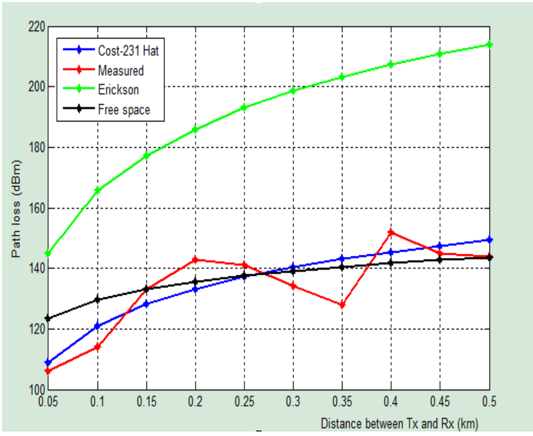

Figure 3: Path loss against distance at 6m receiver height.

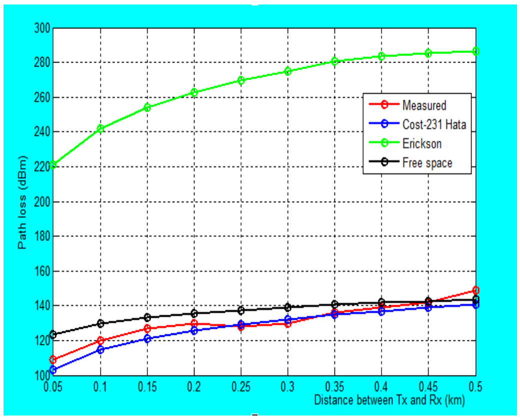

Figure 4 : Path loss against distance at 8m receiver height.

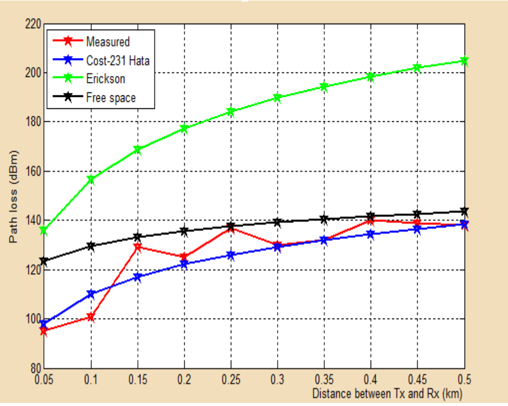

Figure 5 : Path loss against distance at 10m receiver height.

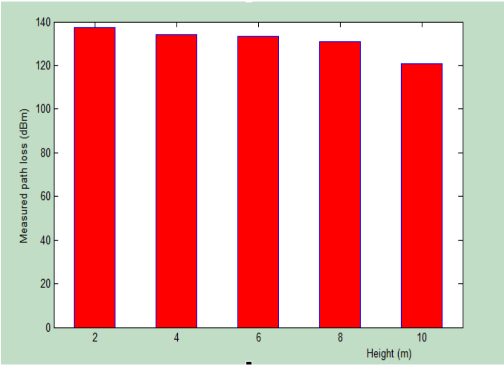

Figure 6 : Measured mean path loss against height

Figure 6 shows that at higher heights level, receiver provides better signals. This is because at higher height less interference occurs and the signal encountered little or no obstacles. Hence, path loss varies inversely with height. At the height 2m, the path loss is 137.40dBm while it is 120dBm at 10m height.

IV. CONCLUSION

In this paper the applicable path loss models are compared with experimental measured path loss at different heights and distances using 900MHz frequency. At this frequency the best fit model is Cost 231-Hata model with μ ranges between 1.46 to 2.90dBm. Results show that at higher heights, receiver provides better signals; this is because at higher height less interference occurs. The result is in good agreement with the acceptable international range $1 \leq \mu \leq 15$dBm. (Wu and Yuan 1998).

V. REFERENCES

[1] B. Castrol, M.Pinheiro, G.Canalcante, “Comparison between known comparison models, using least square tuning algorithm on 5.8GHz in Amazon region cities”, Journal of Microwaves, Optoelectronics application, vol.10,No.1, June 2011.

[2] N. Rakesh and Strivasta S.K, “ An Investigation on propagation path loss in Urban Environments for various models transmitter Antenna height 50m and different Receiver Antenna height” International Journal of Receiver and reviews in Computer Science”, vol.3, No.4. pp 1761-1 August 2012.

[3] Yuvraj Singh “Comparison of Okumura, Hata and Cost-231 Models on the Basis of Path Loss and Signal Strength” International Journal of Computer Applications, vol.59-No.11, December 2012.

[4] S. R Saunders, M.Hata, Empirical formula for Propagation loss in Land Mobile Radio Services, IEEE Transaction on Vehicular Technology, Vol. V7 29 August 1980, pp 317-32

[5] N. Shabbir, M.Sadiq, T. Kashif, and R. Ullah, "Comparison of Radio Propagation Models for Long Term Evolution (LTE) Network”, International Journal of Next generation networks, vol.3, No. 3, September, 2011

[6] V. Erceg, L. Greenstein, “An Empirical Based Path Loss Model for Wireless Channels in Suburban Environments “IEEE Journal on Selected Areas of Communication, vol.17, pp/ 1205-1211, July 1999.

[7] Yu-Huel, T., Wen-Shyang, H., and Ce-Kuen, S. “The Influence of Propagation Environment in a Live GSM Network. Research Paper, Department of Electrical Engineering, National Kaohsiung University of Applied Sciences, Kaohsiung, R.O.C.3-5.

[8] Z. Nadir and M.Idrees Ahmad “Path loss Determination Using Okumura-Hata Model and Cubic Regression for Missing Data for Oman”, Proceedings of IMECS, vol.2, 2010