Nigerian Research Journal of Engineering and Environmental Sciences 2(1) 2017 pp. 115-122

Nigerian Research Journal of Engineering and Environmental Sciences
Journal homepage: www.rjees.com

RJEES

Original Research Article

JUSTIFICATION OF THE NON APPLICABILITY OF FREE SPACE PATHLOSS MODEL FOR TELEVISION PLANNING IN EDO STATE, NIGERIA

***Ogbeide, K.O. and Ekoko, E.C.**

Department of Electrical/Electronics Engineering, Faculty of Engineering, University of Benin, Benin City, Nigeria
*kingsley.ogbeide@uniben.edu

ARTICLE INFORMATION

Article history:
Received 11 March 2017
Revised 31 March 2017
Accepted 04 April 2017
Available online 01 June 2017

Keywords:
Pathloss
Television
Signal strength
Free space model
Propagation

ABSTRACT

This study was aimed at testing the reference free space propagation model for television planning in Benin City, Edo State, Nigeria with the view to determining how well it can predict the propagation pathloss scenario in television planning in Edo State. Signal strength measurement campaign of selected television stations (both ultra high frequency UHF and very high frequency VHF television stations) in Benin City was conducted across some selected routes using a hand held spectrum analyzer. The results revealed that for all scenarios, the free space propagation model could not be relied on for effective radio planning as it completely under estimated the path loss situation in Benin City. The effectiveness of the model was determined on the basis of the root mean square error whose values exceeded the acceptable 6 dB for radio propagation planning in both the VHF and UHF signal propagation.

© 2017 RJEES. All rights reserved.

1. INTRODUCTION

Propagation models are usually used in the planning of communication systems like the television broadcasting system. It has been reported that the free space propagation model was unfit for television planning in the middle belt of Nigeria (Obiyemi et al., 2012), but this has not been tested in Edo State. Thus there is need to test the applicability of this model in this current environment of investigation.Television system as an electronic communication involves the sending, receiving and processing of audio-visual information by electronic means (George and Bernard, 2003). In a television system, the information source produces a message or sequence of messages to be processed in the transmission section of the communication system. The transmitter then processes the message in some way to produce a signal suitable for transmission over the channel (Sanjay, 2010). The transmitter converts low frequency or baseband information to a high frequency or radio frequency (RF) signal which is then radiated via the antenna. The path that a radio wave radiated from the antenna takes to get to the receiver is normally very random (Theodore, 2002). Once a radio signal has been radiated by the antenna, it travels or propagates through space and ultimately reaches the receiving antenna. The energy level of the radio signal decreases rapidly as the signal can take one or more different paths to the receiving antenna. The path that a radio signal takes depend on the frequency of the transmitted signal and also on the prevailing terrain (Maitham and Asrar, 2003).

Propagation models can be used to plan the location of broadcasting stations, and also to determine the antenna height and transmitting power of a new broadcast transmitter when a certain coverage area is to be served. They can be used to calculate possible interference on the coverage area of another transmitter that is already on air. For example, when a country is planning to operate a new television broadcasting station, it is required to follow certain rules and procedures to ensure that no interference is posed to existing broadcasting stations in adjacent countries. These rules and procedures generally prescribe the use of a specific propagation model.

In designing any radio system, a fundamental task is to predict the coverage of a proposed system and determine whether the intended service objectives are met. Propagation modeling is an effort to predict signals as they propagates from the transmitter to the receiver. In order to find out the suitable propagation model(s) applicable for propagation prediction in Edo State, certain propagation models are considered and evaluated using some known statistical tools. The propagation model selected for this study is the free space reference model. This reference- propagation model have been developed with the intention of only predicting signal attenuation or pathloss as the signal propagate from the transmitter to the receiver (Obot and Afolayan, 2011).

2. FREE SPACE PROPAGATION MODEL

The free space propagation model assumes the ideal propagation condition that there is only one clear line-of-sight path between the transmitter and receiver. Equation (1) is the free space pathloss model for received signal at distance d from the transmitter (Pardeep et al., 2014). Accordingly, the free space path loss (FSPL), is very important for carrying out radio calculations during the planning stage especially for relatively short transmitter to receiver distance where the signal propagation would be without any barriers and obstacles.

$$L_{FS}=20\log\frac{4\pi df}{c} \tag{1}$$

Where c is the signal speed in vacuum, d is the distance between transmitter and the receiver and f is the frequency of transmission.

In terms of decibels, the basic free space path loss equation can be expressed in a logarithmic form as

$$\text{FSPL (dB)} = 32.5 + 20 \log_{10} (d) + 20 \log_{10} (f) \tag{2}$$

3. UHF/VHF SIGNAL MEASUREMENT

To measure the signal strength of the television broadcasting stations, a portable spectrum analyzer (Sefram 7806 analyzer) was used. It is a battery operated hand-held RF field strength meter capable of measuring radio frequency levels. The instrument provides a reliable measurements across a wide reception range of 45 to 865MHz.

Figure 1: Sefram 7806

Figure 2: Garmin 78cs GPS receiver

A handheld global positioning system (GPS) –Garmin GPS 76CS receiver was used for obtaining the spatial coordinates of the various measuring points in angular degrees. Figures 1 and 2 show a picture of Sefram 7806 and the GPS receiver respectively.

Recording of each measurement started at the television broadcasting station (under consideration) where the signal strength and GPS measurements were carried out. Thereafter measurements were taken at different points. The distance was chosen to allow for sufficient change in signal strength from the previous measurement points. To begin measurement, the hand held signal strength meter was pre- set to the frequency of the television stations to be monitored. Table 1 shows the frequency allotted to each of the television broadcasting stations by the Nigeria Broadcasting Commission.

Table 1: Characteristics of television broadcasting stations

Station	Transmit frequency (MHz)	Transmitter height (m)	Channel	Transmitter power (kW)	Frequency band
NTA Benin	189.25	450	7	10	VHF
EBS TV	743.25	750	55	10	UHF
ITV	479.25	1000	22	10	UHF

K.O. Ogbeide and E.C. Ekoko / Nigerian Research Journal of Engineering and Environmental Sciences
2(1) 2017 pp. 115-122

At the measurement point, the signal strength of each station was taken and stored in the measuring device memory. The drive test was facilitated by a route map of Edo State obtained from the Ministry of Lands and survey. The route were selected such that it formed a radial around the broadcasting stations.

To show the pathloss variability with distance for signal from the UHF/VHF broadcasting stations the available data of the television broadcasting station under investigation was inputed into the free space path loss equation to obtain Equations (3) to (5).

For EBS television operating at 743.25MHz

$$FSPL\ (dB) = 32.5 + 20\log(d) + 20\log(743.25)$$

$$= 89.92 + 20\log(d) \quad (3)$$

For ITV operating at 479.25MHz

$$FSPL\ (dB) = 32.5 + 20\log(d) + 20\log(479.25)$$

$$= 86.11 + 20\log(d) \quad (4)$$

For NTA operating at 189.25MHz

$$FSPL\ (dB) = 32.5 + 20\log(d) + 20\log(189.25)$$

$$= 78 + 20\log(d) \quad (5)$$

4. RESULTS AND DISCUSSION

The field strength values measured for each station were converted into a path loss value called "measured path loss". Path loss values were computed for the free space propagation model using the Equations (3) to (5). The obtained path loss was compared to that of the measured path loss and the results are shown in Figures 3 to 8.

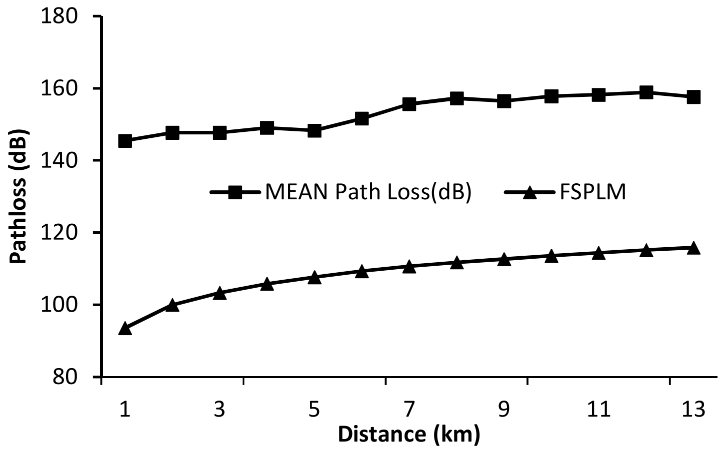

Figure 3: Pathloss curve for EBS signal-route 1 (Aduwawa-Bypass route)

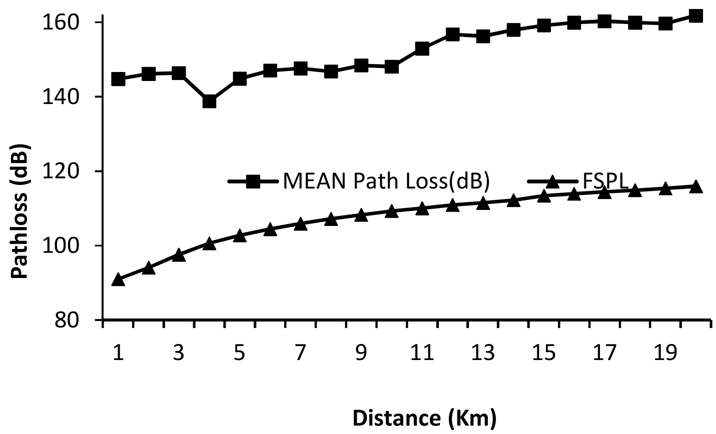

Figure 4: Pathloss curve for EBS signal-route 2 (Aduwawa- Akpakpa route)

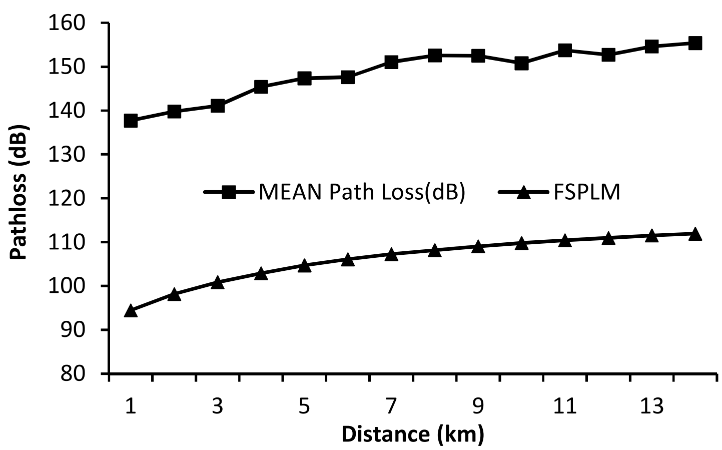

Figure 5: Pathloss curve ITV signal-route 1 (Iguosa-Bypass route)

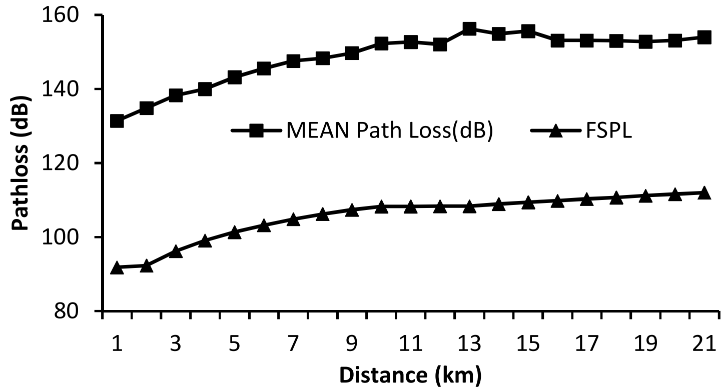

Figure 6: Pathloss curve for ITV signal-route 2 (Iguosa-Akpakpava route)

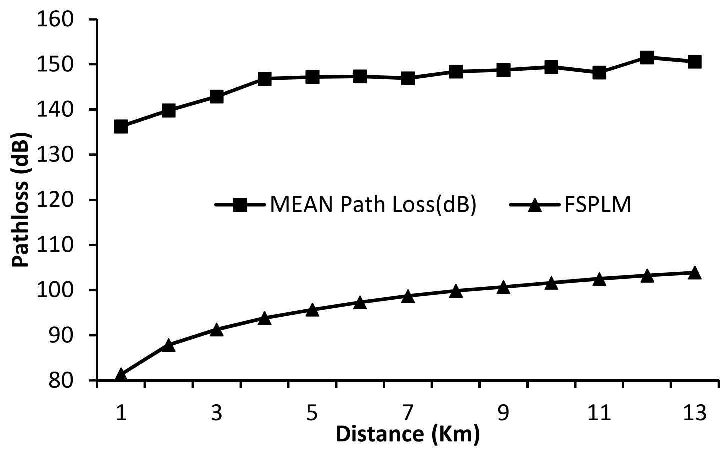

Figure 7: Pathloss curve for NTA signal-route 1 (Aduwawa-Bypass route)

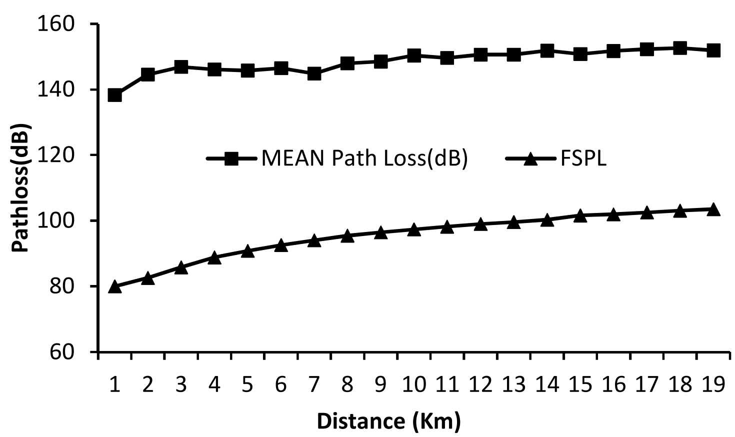

Figure 8: Pathloss curve for NTA signal-route 2 (Aduwawa-Akpakpava route)

As observed from Figures 3 to 8, the measured pathloss reveal some deviations from the pathloss obtained from the prediction model. Two commonly used statistical tools for evaluating propagation models are the mean prediction error (MPE) and the root mean square error (RMSE) (Obot and Afolayan, 2011; Ubom et al., 2011; Nasir et al., 2013). The root mean square error is a frequently used measure of the difference between values predicted by a model and the values actually observed from the environment that is being modeled (Slawomir and Ryszard, 2011).The RMSE of a model prediction with respect to the estimated variable X_{model} is defined as the square root of the mean squared error (Ubom et al., 2011).

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n} (X_{obs,i} - X_{model,i})^2}{n}} \quad (6)$$

$$MPE = \frac{\sum \left(X_{Obs,i} - X_{model} \right)}{n} \quad (7)$$

Where X_{obs} is observed values and X_{model} is modelled value.

The MPE and RMSE were determined for each of the route as shown in Table 2. From the Table 2, it can be seen that for all the routes investigated, the free space pathloss model gave an excess of 6 dB which is allowed for model adoption in an environment.

Table 2: Computed mean prediction error and RMSE values from model

ROUTES	EBS (dB)		ITV (dB)		NTA (dB)	
	MPE	RMSE	MPE	RMSE	MPE	RMSE
ROUTE 1	44.41	46.03	42.59	42.59	49.75	49.8
ROUTE 2	44.48	44.65	42.96	42.99	51.36	51.56

4. CONCLUSION

The study has shown that the free space pathloss model greatly under-predict the actual pathloss as revealed by signal measurement and this is a justification while it is not a reliable propagation model for television system planning in the VHF and UHF band spectrum in Edo State. Thus this model must never be used for most terrestrial television planning even though it can be used as a basis for understanding many real life radio propagation situations. However for the case of television planning in Edo State, the Free space model is grossly inadequate as depicted by the high values of the mean prediction errors and the root mean square errors. In all cases, the RMSE values for both the UHF and VHF signals exceeded the 6 dB value accepted for the deployment of radio model in an environment.

5. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

REFERENCES

George, K. and Bernard, D. (2003). Electronic Communication Systems. *Tata Mcgraw-Hill Publishing Company Limited*, 7th ed. pp. 1-4.

Maitham, A. and Asrar, U.H. (2003). Signal strength prediction in the VHF band in the eastern region of Saudi Arabia. *The Arabian journal for science and engineering,* 28(2), pp. 1-5.

Nasir, F., Adeseko, A. and Yunusa, A.A. (2013). On the study of empirical pathloss models for accurate prediction of TV signal for Secondary users. *Progress in Electromagnetics research*, 49(1), pp. 155- 176

Obiyemi, O.O., Ibiyemi, T.S., Ilori, G. and Ojo, J.S (2012). Path loss model for radio wave propagation at VHF/UHF bands using electric field strength measurement over Ilorin middle belt, Nigeria, *Proceedings of 2nd International Conference on Advances in Computational Tools for Engineering Applications (ACTEA, 2012), Notre Dame University, Beirut, Lebanon*, pp. 43-46.

Obot, O.S. and Afolayan, J. (2011). Comparative analysis of path loss prediction models for urban macrocellular environments. *Nigerian Journal of Technology,* 30(3), pp. 50-59.

Pardeep, P., Parveen, K. and Shashi, B. (2014), Performance Evaluation of different Path Loss Models for Broadcasting applications. *American Journal of Engineering Research (AJER)* 3(4), pp. 335-342.

Sanjay, S. (2010). Communication Systems (Analog and Digital), *S.K. Kataria & Sons* 5th ed, pp 7-13

Slawomir, J.A. and Ryszard, J.K. (2011). The Selected Propagation Models Analysis of Usefulness in Container Terminal Environment *ICWMC 2011: The Seventh International Conference on Wireless and Mobile Communications.*

Theodore, S.R. (2002). Wireless Communication Principles And Practice, Prentice *Hall Inc.* 2nd ed, pp 84-104

Ubom, E.A., Idigo, V.E., Azubogu, A.C., Ohaneme, C.O. and Alumona, T.L. (2011). Path loss Characterization of Wireless Propagation for South – South Region of Nigeria. *International Journal of Computer Theory and Engineering,* 3(3), pp. 360-364.