

Investigation of Error Margin of Some Path Loss Models Over Digital Terrestrial Television Channel in Katsina Metropolis



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ABSTRACT

Due to rapid development in mobile communication technology in recent times, strong signal coverage has become a major necessity. However, path loss is one of the major challenges against strong signal coverage. Several path loss models have been developed for predicting wireless signal coverage for urban, sub-urban and rural areas. However, the need to investigate which model can best predict losses in an environment becomes necessary. This work is aimed at comparing the Error Margin of some Path loss Models over Digital Terrestrial Television (DTTV) channel using the Star Times DTTV Channel within Katsina metropolis. Seven path loss predicting models for outdoor macro cell wireless communication were used. They are; Free Space model, COST-231 model, (developed by the European Union Co-operative for Scientific and Technical Research Team) Hata - Okumura model, Plane Earth model, Okumura model, Ericson model and ECC model. The measurement campaigns were in two seasons, the wet season was in August and dry season in November, 2021. Both measured and predicted path loss values were computed using empirical models. Statistical error analysis based on the RMSE was carried out to determine the error margins between measured and predicted values. Based on the result of path loss assessment and error analysis, COST-231 with the lowest RMSE value of 13.49 dB which is within the acceptable range for sub-urban city is the most preferred amongst the investigated models for path loss prediction over digital UHF channel in Katsina city.

Keywords:

Error Margin,
Path Loss,
DTTV,
RMSE,
Coverage Failure.

INTRODUCTION

Due to the rapid development in Mobile communication technology in recent time, the demand for high quality and high-capacity network with thorough coverage and less cost of managing path loss of electromagnetic wave transmission has become a major necessity (Mardeurin & Lee Yin Pey, 2010). Path loss could be due to several factors which include the terrain, distances between the receiver and the transmitter, temperature, vegetation (foliage), building structures in urban areas and many more (Akinbolati *et al.*, 2018).

With the rise in number of radio base stations aiming at improving the quality of service and coverage area of transmitted signals, accurate prediction of path loss for efficient power budget is required to achieve these goals. An important topic in networks planning is the power loss prediction and the interference analysis. There are two kinds of models regularly used for path loss prediction they are, deterministic and empirical models.

Since 1999, the introduction of the Global System for Mobile Communication (GSM) and the Code Division Multiple Access (CDMA) technology has made a huge thrust to wireless communication system in Nigeria (Abiodun, 2017). Since 2003 also, there has been a tremendous growth in the communication industry in Nigeria. Likewise in the broadcasting industry, more television base stations were established, thereby shifting from analogue to digital broadcasting technology. To maintain this upwards growth, the need for accurate predictions of path loss for optimum performance of the wireless network services become necessary, so that the subscriber's expectations as well as customer level agreements are met (Kozono & Taguchi, 1989). These have led to drastic increase in demands for mobile connectivity and wireless networks, and therefore called for optimization of the available Television White Space (TVWS) (Abiodun, 2017).

The major design consideration of a cellular system depends on the path loss. The path loss occurs due to the

type of terrain and reflection of the signal from the obstacles. The transmission path may be line of sight or may vary between the transmitter and the receiver, depending on the obstacles like buildings, mountains or foliage. Due to the different obstacles present in the transmission path, multiple reflections occur and the electromagnetic wave then travels through different paths. This causes multipath fading at a specific location and the strength of the wave decreases as the distances between the transmitter and the receiver increases. If the receiver happens to be located in a deep fade this will result in a substantial decrease in signal strength.

Major factors that affect the signal strength at any given location are, distance between the transmitter and the receiver, height of the transmitter and receiver antenna, power of the transmitting base station and the carrier frequency, the topography of the terrain between the transmitter and the receiver in the signal path (Akinbolati *et al.*, 2020). Fading can also produce major variation in signal strength relative to the mean level at any location (Wahl *et al.*, 2017). Many Propagation models have been developed. Microcell environment has substantially increased with advent of terrestrial telecommunication technology (Nizirat *et al.*, 2011). This has led to setting up smaller frequently used base stations also known as booster stations.

In addition, foliage and building structures always cause multiple refractions as they allow the signals to be reflected in to different directions. The topology of the terrain may contain hills and valleys that can obstruct the transmitted signals thereby reducing the signal strength.

Review of Related Literature and Basic Theory

Okumura *et al.* (1968) investigated the field strength of VHF and UHF land mobile radio services in Tokyo Japan, this study was based on field strength measurement in Japan only, the result was widely accepted, however it was not suitable for use in irregular terrain as the study was limited to frequency range of 150-1500 MHz. Hata - Okumura (1980) proposed path loss model based on land mobile communication. This was reformation of Okumura Model capable of being used in urban suburban and rural areas, and applied correction factors. It was accepted by ITU Not suitable use in irregular terrain, but was limited to frequency range of 150-1500 MHz. Davidson, (1987), in May 1997 worked on technology independent methodology for the Simulation and empirical verification of wireless communication system, performance in noise and interference: This is limited to system operating on frequencies between 30 and 1500 MHz” working group of IEEE vehicular technology society propagation committee, only. Nadir *et al.* (2008), carried out an investigation on the characteristics of radio propagation by taking measurement at a small town in Purwokerto,

Central Java Indonesia. Their findings were compared with Okumura Hata and Lee’s models so as to evaluate the path loss prediction thereby improving on their accuracy.

Armoogum *et al.* (2010), conducted the research in Nigeria in 2010. The author investigated important of the propagation models when designing new broadcast network based on field strength only. The comparison was done using Okumura Hata model. But the process involves a large number of expensive input data requirement, in the process no new model could be proposed. Abiodun, (2017), carried out the research on assessment of path loss prediction models for wireless propagation channels at L-band frequency over different micro cellular environment of Ekiti state. The results of the adaptability of radio channels behavior were presented based on practical measurement carried out in the 1800 MHz frequency band. The measurements were carried out in the typical urban, suburban and rural environment in Ekiti state, southern part of Nigeria. The proposed model and regression line exhibited lowest standard deviations followed by the COST 231 and HATA models when compared with the Ericsson and SUI models. But information from this work will only be useful for link design of micro wave band wireless system in this region alone. Mejia *et al.*, (2012), Studied and developed a model for urban micro cell radio propagation prediction focused on reliable implementation. The model foundation was the creation of many different virtual sources, for that reason a technique for limiting the number of sources created without loss accuracy was proposed. The work was carried out at Bucaramanga, Colombia in the year 2012. The main aim is to achieve an easy and reliable algorithm implementation, then the assignment of radiation pattern using ray-tracing radioactive energy transfer (RET) theory or uniform diffraction theory (UTD). This model is for urban micro cell prediction only which would play a key role in planning UHF wireless networks. In 2013, Faruk *et al.* (2013), did research on the study of empirical path loss models for accurate prediction of television signals for secondary users at Ilorin, Kwara state, Nigeria. In this work they assessed the fitness of nine empirical widely used path loss models using five novel metrics to gauge their performance. To achieve this, field strength measurements were conducted in the VHF and UHF regions along six different routes that spanned through the urban, suburban and rural areas of Kwara state. The result shows no single model provide a good fit consistently. But environmental factors were not put into consideration. Root Mean Square Error, (RMSE), Spread Corrected Root Mean Square Error (SC-RMSE), Error distribution and probability density function were used. Akinbolati and Agunbiade, (2019) carried out the study of error bounds of empirical path loss model, over

UHF band in Ekiti State, Nigeria, by field strength measurement in urban, suburban and rural areas of Ekiti state, Nigeria. Eight prediction path loss models were investigated with five error analysis metrics used; Root Mean Square Error (RMSE), Square Corrected Root Mean Square Error, (SC-RMSE), Error Distribution and Probability Density Function was used to evaluate the performance of the models. The study recommended the Electronics Communication Committee (ECC) model for use over UHF Channel in the study area. Similarly, Akinbolati and Ajewole (2020), worked on the investigation of path loss and modeling over digital terrestrial television channels in Nigeria. The research areas were over Ikorodu-Lagos, Kaduna and Katsina Cities. Calculations and comparison were based on Hata models. Hata modified new models that incorporate some tropospheric parameters were proposed.

Power Density

Power density is defined as the radiated power per unit area. It is inversely proportional to the square of the distance from the source and directly proportional to the transmitted power. This is the inverse square law, which universally applies to all forms of radiation in free space, they are as presented in (1)-(3) (Akinbolati *et al.*, 2016):

$$P_d \propto 1/r^2 \quad (1)$$

$$P_d \propto P_t \quad (2)$$

$$P_d = P_t / 4\pi r^2 \quad (3)$$

where P_d is the power density at a distance r , from an isotropic source, P_t is the transmitted power. The electric and magnetic field intensities of electromagnetic waves are the direct counterparts of voltage and current in electrical circuit. They are measured in V/m and A/m respectively. In electrical circuits we have:

$$V = ZI \quad (4)$$

where, I , is the current and Z is impedance or resistance, while in electromagnetic waves;

$$\vec{E} = Z\vec{H} \quad (5)$$

where Z is the characteristic impedance of the medium in Ω , \vec{E} , is the r.m.s value of field strength in (V/m) and \vec{H} is the value of the magnetic field strength (A/m) for free space;

$$\vec{E} = Z_0 \vec{H} \quad (6)$$

with the characteristic impedance (Z_0) known, it is now possible to calculate the field intensity at a distance r , from an isotropic source e.g. the transmitter. In an electrical circuit:

$$\text{Power} = \frac{V^2}{Z} \quad (7)$$

V is the voltage; Z is the resistance or impedance. In electromagnetic wave propagation;

$$P_d = \frac{|E|^2}{Z_0} \quad (8)$$

where, P_d is the power density and $|E|$ is the magnitude of the electric field strength, recall (3)

$$P_d = P_t / 4\pi r^2$$

Equating (8) and (3):

$$\frac{|E|^2}{Z_0} = \frac{P_t}{4\pi r^2} \quad (9)$$

$$|E|^2 = \frac{P_t Z_0}{4\pi r^2} \quad (10)$$

$$\text{But } Z_0 = 120\pi$$

$$|E| = \sqrt{\frac{30P_t}{r^2}} \quad (11)$$

At distance r from the transmitter, the electric field strength is represented as;

$$|E| = \frac{\sqrt{30P_t}}{r} \quad (12)$$

$|E|$ is in volt/meter, r is in meters, P_t is the power transmitted in watts (Boithias, 1987; Akinbolati *et al.*, 2016).

Empirical Models and Methodology Used for the Study

Free Space Model (LFSP)

Free space model depends on frequency and distance. It is calculated as:

$$L_{f_{psl}} = 32.45 + 20\log_{10}(d) + 20\log_{10}(f) \quad (13)$$

where, f is the frequency in (MHz) and d is the distance between transmitter and receiver measured in kilometers.

Plane Earth Model (LPE)

The free space model doesn't recognize the impacts of proliferation over the ground. At the point when a radio wave proliferates over ground, a part of the power will be reflected due to nearness of the ground and the receiver. The information needed for the calculation is the height, the distance of separation and the reflection coefficient of the earth. The path loss equation for plane earth model is (Ranvier, 2004):

$$L_{pe} = 40\log(d) - 20\log(h_1) - 20\log(h_2) \quad (14)$$

where f is the frequency in (MHz), d is the distance from the base station to the receiver in (km), h_1 and h_2 in (m) are the heights of the transmitting base station and receiving antenna respectively.

Okumura Model (OKUM)

Is a radio propagation model that was built using data collected in the city of Tokyo, Japan (Okumura, 1968). The model is ideal for use in cities with many urban structures but not with many tall blocking structures. It was built into three models:

For urban, suburban and open areas (Okumura, 1968)

The Okumura model was formally expressed as:

$$L = L_{FSL} + A_{MU} + H_{MA} - H_{BA} - \sum K_{CORRECTION} \quad (15)$$

where, L is the median path loss in dB, L_{FSL} is the free space loss in dB, A_{MU} is median attenuation, H_{MA} is mobile station antenna height gain factor, H_{BA} is based station antenna height gain factor, $K_{CORRECTION}$ is correction factor gain.

ECC-33 Models

(Electronic Communication Committee) This model extrapolated the original measurements by Okumura and modified its assumptions so that it is more closely represents a wireless system (Nizirat *et al.*, 2011):

$$L = A_{fs} + A_{bm} - G_b - G_r \quad (16)$$

Where, A_{fs} , A_{bm} , G_b , and G_r are the free space attenuation, the basic media path loss gain factor, the receiver gain factor and transmitter gain factor respectively.

They are usually defined as:

$$A_{fs} = 92.4 + 20 \log d + 20 \log f$$

$$A_{bm} = 20.41 + 9.83 \log d + 7.89 (\log f)^2$$

$$G_b = \left[\frac{\log(hf)}{200} \right] [13.958 + 5.8 \log(d)]^2 \quad (17)$$

This is for medium city environments (Danosso, 2020)

$$G_r = [42.57 + 13.7 \log(f)][\log(h) - 0.585] \quad (18)$$

For large city,

$$G_r = 0.759h - 1.862 \quad (19)$$

Where f is the frequency in GHz, d is the distance between base station and mobile antenna in km and h is the base station antenna height in m.

COST- 231 model (European Cooperative for Scientific and Technical Research)

It is widely used for predicting Path loss in mobile wireless system.

It is designed to be used in the frequency band of 500 - 2000 MHz. It contains correction factor for urban, suburban and rural (flat) environment.

The basic equation for this Path loss model in dB is COST-231 (1991):

$$L = 46.3 + 33.9 \log f - 13.82 \log h_b + C_m - a_{hm} + (44.9 - 6.55 \log h_b) \log d \quad (20)$$

where, f , is the frequency in MHz, d is the distance from the base station to the mobile antenna in km, h_b is the base station antenna height above the ground, C_m is 0 dB for suburban or open environments and 3 dB for urban environments.

$$a_{hm} = 3.2 (\log 11.75 h_r)^2 - 4.97 \quad (21)$$

$$f > 400 \text{ MHz}$$

And for Suburban

$$a_{hm} = (1.1 \log f - 0.7) h_r - (1.56 \log f - 0.86) \quad (22)$$

The HATA Model (HATA)

It is a radio propagation model for predicting the path loss of cellular transmission in exterior environments, valid for microwave frequencies from 150 - 1500 MHz. It is an empirical formulation based on the data from Okumura model and this also commonly referred to as the Okumura- Hata model. It is an empirical formulation of the graphical Path loss data provided by Okumura's model.

It is expressed as follows (Akinbolati and Ajewole, 2020):

$$L(\text{urban}) = 69.55 + 26.16 \log f - 13.82 \log h_{te} - a_{h_{re}} (44.9 - 6.55 \log h_{te}) \log d \quad (23)$$

where f , is the frequency (MHz) 150 - 1500 MHz, h_{te} is the effective height of the base station, h_{re} is the mobile antenna height, d is the distance from the base station to the mobile antenna, $a_{h_{re}}$ is the correction factor for the effective antenna height of the Mobile unit,

$$a_{hm} = 3.2 (\log 11.75 h_r)^2 - 4.97 \quad (24)$$

Ericsson Model (ERIC)

It is the software provided by Ericsson Company for network planning for Engineers. It stands on the modified Okumura - Hata model which is given as follows (Abiodun, 2017)

$$L = a_0 + a_1 \log(d) + a_2 \log(h_b) + a_3 \log(h_b) \log(d) - 3.2 \log(11.75 h_r)^2 + g(f) \quad (25)$$

$$\text{where } g(f) = 44.49 \log(f) - 4.78 \log(f^2)$$

Performance Evaluation Metrics Used in this Study

Three metrics were used in the performance evaluation of the seven models deployed in this work. Those metrics are: Root Mean Square Error (RMSE), Spread Corrected RMSE, the Prediction Error.

Root Mean Square Error (RMSE)

This is dependent on the prediction Error of distance from the base station. The prediction Error is given by:

$$\varepsilon = |P_1 - P_m| \quad (26)$$

Where, P_1 is the measured path loss at distance I , P_m is the predicted path loss.

From the above equation, the overall, RMSE for a given model (m) and a given data set (n) is defined as:

$$RMSE = \sqrt{\frac{1}{n} \sum_{i=1}^m |P_1 - P_m|^2} \quad (27)$$

When the value of the RMSE is closer to zero, it means a better fit but the acceptable RMSE value is between 6 and 7 dB for urban areas and 10 - 15 dB for suburban and rural area. The RMSE was used mainly in this study to predict the error margin because of its wide acceptability in error prediction and have been used in similar studies (Akinbolati and Agunbiade, 2020; Blaustein *et al.*, 2013; Abhayavardhana *et al.*, 2005).

Spread Corrected Root Mean Square (SC-RMSE)

This is used to get the effect of dispersion from the overall evaluated error. It is computed the same way as RMSE, but differs only in the subtraction of the standard deviation from the absolute value of the error calculated.

$$SC-RMSE = \sqrt{\frac{1}{n} \sum_{i=1}^n (\varepsilon'')^2} \quad (28)$$

where $\varepsilon'' = (\varepsilon) - \delta_1$

Conversions Used in this Study

In order to convert measured transmitted power in kilowatts to dBm (decibel per meter)

$$P(dBm) = 10 \log[P_{t(kw)} \times 1000] + 30 \quad (29)$$

The above equation is the conversion of power in kilowatt to power in dBm.

For conversion power from dBm to dB:

$$dB = 10 \log \left[\text{Inv. log} \left(\frac{P(dBm)}{10} \right) \times 1000 \right] \quad (30)$$

The Measured Path Loss (MPL) values in this study were computed using:

$$P_l = P_{t(dB)} - P_{r(dB)} \quad (31)$$

where, $P_{t(dB)}$ is the power transmitted by the station in decibel and $P_{r(dB)}$ is the power received at that point.

Instruments and Methods of Data Collection

Measurement of power intensity of the signal was taken at consecutive distance intervals of 1km each, starting from the base station of Star Times Television station within Katsina metropolis. Measurement of field strength was taken using digital field strength meter (WS-6936). Geographic coordinates of the locations were taken using GPS. The Line of Sight (LoS) from the base station as well as the geographic heights were measured at the same time. Data were collected by method of Drive Test, for both the dry and wet season months in August and November 2021. In this Drive Test method of collecting data, an antenna of 3m height was mounted on a car for taking the readings. Measurements were carried out along three selected routes during the wet and dry season months. The routes are: Katsina - Jibia (route A), Katsina - Daura (route B) and Katsina - Dutsin-Ma (route C). The transmission and reception parameters for the field measurements are: Base Station Antenna Height, 200 m, Mobile Station Antenna Height, 3 m, Power Output, 2.6 kW and Frequency of Transmission, 530 MHz.

RESULTS AND DISCUSSION

Tables 1a and 1b present the calculated mean values for the path loss (measured and predicted) for the three routes investigated and the overall mean values during the wet season month respectively. Similarly, Tables 2a and 2b present results for the dry season month.

Table 1a: Mean values for the three routes for both measured and predicted path loss during wet season month over Katsina

Route	FSPE (dB)	LPE (dB)	COST231 (dB)	ERIC (dB)	Okum (dB)	ECC33 (dB)	Hata (dB)	MPL (dB)
Katsina– Jibia	106.45	20.06	142.37	140.37	38.05	180.63	40.19	126.15
Katsina– Dutsin-ma	109.34	29.06	150.28	146.13	40.01	185.36	43.60	128.83
Katsina– Daura	109.71	26.06	149.78	145.67	42.92	185.50	41.02	134.53

Table 1b: Overall mean values for the three routes for both measured and predicted path loss during wet season over Katsina

Measured Path Loss, MPL (dB)	FSPE (dB)	LPE (dB)	COST231 (dB)	ERIC (dB)	OKUM. (dB)	ECC33 (dB)	HATA (dB)
129.84	108.5	25.06	147.46	144.07	40.33	183.83	41.60

Table 2a: Mean values for the three routes for both measured and predicted path loss during dry season month over Katsina

Route	MPL (dB)	LPE (dB)	COST231 (dB)	ERIC (dB)	FSPE (dB)	Okum (dB)	ECC (dB)	Hata (dB)
Katsina – Jibia	124.41	25.01	142.30	142.01	106.40	38.10	180.43	40.47
Katsina – Dutsin-ma	129.70	20.06	150.28	144.75	109.44	43.27	185.36	38.14
Katsina – Daura	127.36	19.08	149.78	145.67	109.41	42.32	184.50	32.37

Table 2b: Overall mean values for the three routes for both measured and predicted path loss during dry season over Katsina

Measured path Loss, MPL (dB)	FSPE (dB)	LPE (dB)	COST231 (dB)	ERIC (dB)	OKUM. (dB)	ECC33 (dB)	HATA (dB)
127.16	108.42	21.38	147.45	144.15	41.23	183.43	37.00

From Tables 1, and 2, Ericson and COST-231 model have values that are close to the measured path loss values for both dry and wet season months. The obtained mean values for the MPL for both wet and dry season months are 129.84 and 127.16 dB respectively. On the other hand, Ericson model recorded mean values of 144.07 and 145.67 dB for wet and dry season months respectively, while COST-231 recorded mean values of 147.46 and 149.78 for wet and dry season months respectively. The implication of this finding is that both models could be recommended for pathloss prediction over DTTV channel in the study areas. However, the result of the error analysis will be used to further

strengthen the result with a view of coming out with the model that would be better between the two.

RESULTS AND DISCUSSION

Results of Error Analysis using Standard Metrics

Tables 3a and 3b present the statistical values of the Maximum Error, Root Mean Square Error and Spread Corrected Root Mean Square Error for Katsina - Jibia route for wet and dry season months. Similarly, the results for Katsina – Daura route are presented in Tables 4a and 4b for wet and dry season months respectively, while Tables 5a and 5b present that of Katsina-Dutsin-Ma for both wet and dry season months respectively.

Table 3a: Error Analysis for Katsina – Jibia Route during Wet Season (Aug. 2021)

Errors	FSPE(dB)	LPE(dB)	COST(dB)	ERIC(dB)	Okum(dB)	ECC33(dB)	Hata(dB)
Max. Error	32.59	10.92	29.15	63.32	107.49	63.12	21.41
Mean Error	21.48	06.15	15.07	59.06	70.26	53.72	19.16
RMSE	22.36	07.15	18.53	16.56	91.25	52.61	13.20
STD	06.53	03.75	13.16	14.25	09.67	09.45	04.84
SC-RMSE	26.06	09.17	15.69	52.01	97.82	53.67	16.57

Table 3b: Error Analysis for Katsina – Jibia Route during Dry Season (Nov. 2021)

Errors	FSPE(dB)	LPE(dB)	Hata(dB)	COST(dB)	ECC(dB)	Okum(dB)	ERIC(dB)
Max. Error	26.73	3.14	115.09	31.50	27.80	96.13	27.80
Mean Error	15.50	60.11	29.50	21.92	17.31	84.94	17.50
STD	04.9	02.50	11.78	08.49	06.65	06.07	06.52
RMSE	18.75	10.13	79.18	23.43	18.91	85.17	18.91
SC-RMSE	21.83	02.04	36.69	23.01	21.15	90.06	21.28

Table 4a: Error Analysis for Katsina – Daura Route during Wet Season (Aug. 2021)

Errors	FSPE(dB)	LPE(dB)	COST(dB)	ERIC(dB)	Okum(dB)	ECC33(dB)	Hata(dB)
Max. Error	135.34	09.61	25.24	48.48	100.13	78.36	12
Mean Error	122.54	10.53	15.25	31.14	91.61	61.62	58.98
RMSE	24.00	4.11	16.48	18.92	58.40	65.69	51.14
STD	6.0	7.12	6.40	4.35	40.16	98.26	40.12
SC-RMSE	129.34	7.12	18.84	54.13	37.43	60.10	83.45

Table 4.b: Results of Error Analysis Katsina – Daura Route, Dry season (Nov. 2021)

Errors	LFSPE(dB)	LPE(dB)	Hata(dB)	COST(dB)	ECC(dB)	Okum(dB)	ERIC(dB)
Max Error	26.70	12.06	107.75	33.92	66.32	96.13	27.80
Mean Error	18.15	10.12	9.48	21.91	57.65	84.04	17.30
STD	4.93	11.01	6.53	8.49	40.17	60.12	6.53
RMSE	18.70	11.35	9.18	23.40	57.97	84.40	18.90
SC-RME	21.77	13.65	26.3	25.43	62.15	90.01	21.27

Table 5a: Results of Error Analysis for Katsina – Dutsin-Ma Route for Wet season (Aug .2021)

Errors	FSPE(dB)	LPE(dB)	COST(dB)	ERIC(dB)	Okum(dB)	ECC33(dB)	Hata(dB)
Max. Error	36.01	10.53	33.50	26.54	102.32	66.68	125.42
Mean Error	30.49	14.54	18.09	54.60	88.05	54.30	96.52
RMSE	21.49	08.01	20.73	16.59	88.39	54.98	97.86
STD	5.87	8.94	10.31	8.08	18.13	19.10	30.16
SC-RMSE	30.23	6.11	23.19	38.46	84.19	47.58	95.26

Table 5b: Results of Error Analysis for Katsina – Dutsin-Ma Route, Dry season (Nov. 2021)

Errors	FSPE (dB)	LPE(dB)	Hata(dB)	COST-231 (dB)	ECC (dB)	Okum(dB)	ERIC (dB)
Max. Error	26.74	15.01	116.25	29.25	67.55	96.13	27.19
Mean Error	17.47	8.12	29.20	22.86	58.43	84.10	18.63
STD	5.52	8.91	80.22	12.21	30.42	25.72	7.13
RMSE	18.29	11.14	96.17	24.45	58.82	84.41	19.78
SC-RM SE	21.22	6.10	36.03	17.04	37.13	70.41	20.06

In this work, the RMSE was the metric considered for predicting the most preferred amongst the prediction models deployed in this study. This was based on the fact that RMSE has been internationally accepted that when the value is between 5 and 7 dB, it means an accurate path loss prediction for urban, that of suburban and rural area is between 10 to 15 dB (Blaustein, *et al*, 2011; Akinbolati and Ajewole, 2020). This metric was used on the two models (COST-231 and Ericson) with the closest predicted path loss values in order to recommend a better model out of the two. COST-231 has RMSE mean values of 11.67 and 15.31 dB for wet and dry season months respectively with an overall value of **13.49 dB**. Similarly, Ericson model has 17.35 and 19.91 dB for wet and dry season months respectively with overall mean value of **18.27 dB**. Based on this result, COST-231 with the lower RMSE value of **13.49 dB** and the value is within the acceptable range for sub-urban city is the most preferred for path loss prediction over digital UHF channel in Katsina city.

CONCLUSION

This study investigated the performance evaluation of some path loss prediction models over a sub -urban city of Katsina, Nigeria. Data were collected through field strength measurements during wet and dry season months. Both the measured and predicted path loss values were computed using empirical models. Statistical error analysis based on the RMSE was carried out to determine the error margins between measured and predicted values. Based on the result of path loss assessment and error analysis, COST-231 with the lowest RMSE value of **13.49 dB** which is within the acceptable range for sub-urban city is the most preferred for path loss prediction over digital UHF channel in Katsina city.

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