Fjrs.futa.edu.ng
FUTA Journal of Research in Sciences
ISSN: 2315 – 8239 (Print); E-ISSN: 2489 - 0413

FUTA Journal of Research in Sciences, Vol. 15(2), October, 2019: 277-285

COMPARATIVE STUDIES ON PROPAGATION LINKS FOR DIGITAL TERRESTRIAL TELEVISION SIGNAL IN THE TROPICAL RAINFOREST AND SAHEL SAVANNAH CLIMATIC ZONES OF NIGERIA

*** A. Akinbolati, [2] M.O. Ajewole, [2]Adediji A. T. and [2] J.S. Ojo**

*Department of Physics, Federal University Dutsin-ma, Katsina State, Nigeria.
[2]Department of Physics, Federal University of Technology, Akure, Ondo State, Nigeria.
*CorrespondingAuthor'se-mail;sanmibola2@yahoo.com,aakinbolati@fudutsinma.edu.ng

ABSTRACT
This study investigates the propagation links of two Digital Terrestrial Television Broadcast Stations (DTTBS) in the tropical rain forest (Akure) and Sahel Savannah (Katsina) cities of Nigeria. Digital field strength values of the base stations were measured at intervals of 1km along some selected routes around the stations using a digital signal strength meter. A GPS receiver was used to monitor the line of sight with the station as reference and to log the geographic coordinates and heights of data points. Data were collected in some wet and dry months for a period of two years. Result shows that the Received Signal Strength (RSS) decayed inversely with distance for all the routes and seasons. However, there were few exceptions where some farther trans–receiver distances recorded higher signal strength compared to nearer points contrary to theoretical expectation. This can be attributed to the influences of terrain particularly the elevation above sea level of the study areas and some other factors such as meteorological parameters and surface radio refractivity. Signals were generally enhanced when receiver antenna height of 3.0 m was used compared to the values obtained when using the receiver antenna height of 1.5 m. Signal strength enhancement attributed to higher receiver antenna was more pronounced during the wet season compared to the dry season in Akure. However, the enhancement was relatively consistent for both seasons in Katsina. The average distances in which the signal strength decays to about half of its initial value in Akure and Katsina were **8.0** and **10.0 km** (LOS) respectively. From the statistical analysis of data, mean values of elevation over the study areas were **357.07 m** and **523.97 m** in Akure and Katsina respectively. In addition, mean values of **0.53** and **0.80** positive correlation coefficients were obtained between RSS and elevation above sea level of study locations in Akure and Katsina respectively. Results further revealed that digital terrestrial television signal suffers lesser attenuation in the Sahel Savannah region compared to the tropical rainforest zone. The overall findings of this work will be useful for planning DTT links and network over the study areas.

Key Words: Digital Terrestrial Television, Propagation links, Elevation and NTA-Star times

INTRODUCTION
The quest to enhance Quality of Service (QoS) for Terrestrial Television Transmission and maximize frequency spectrum by releasing the upper UHF bands (Channels 61 to 69) for broadband services necessitated the world wide migration from Analogue to Digital Terrestrial Television (DTT). It was first proposed by General Instrument Corporation (GIS) in 1990 and later adopted by the International Telecommunications Union (ITU agreement on Digitization, 2006).

Some of the advantages of DTT over the Analogue Terrestrial Television (ATT) include transmission of digital signals which requires lesser band width, access to sharp and high definition TV reception, access to more channels for transmission and inclusion of data transmission in TV broadcasting amongst others (Armoogum, *et al*., 2010). Many developed countries have switched from ATT to DTT. In Africa, only a few countries have achieved full digitization with majority still on the ATT, other countries that have partially switched over from ATT to DTT including Nigeria. Nigeria has missed two deadlines (June 17, 2015 and June 17, 2017) for Analogue Switch Off (ASO) and Digital Switch Over (DSO) (Broadcasting Organization of Nigeria (BON, 2017). As the government is busy with policy and logistics to achieve full Digital Switch Over (DSO) so also radio scientists and engineers should be engaged with scientific studies that will ensure QoS and networking for DTT in Nigeria.

Just as the analogue TV signal suffers attenuation from source to destination (Akinbolati, *et al.,* 2016 and 2017), so also a correctly formatted Digital Terrestrial Television (DTT) signal is exposed to various attenuation factors that can degrade it before it reaches the intended users (Akinbolati, *et al*., 2015 and Armoogum, *et al.,* 2010). The medium of propagation for both analogue and digital terrestrial television is the troposphere, where most weather phenomena occur (Akinbolati, *et al.,* 2017 and Boithias, 1987). Also, during transmission, an interaction between radio wave and the environment (propagation paths inclusive) leads to attenuation (Ajewole, *et al., 2013 and 2014;* Boithias, 1987; Kennedy and Bernard, 1992). There is also the attenuation effect on UHF signal caused by precipitation (Ajewole, *et al.*, 2014) and foliage (Ayekomilogbon, *et al*., 2013). Other factors leading to distorted received signal strength are multipath effects and fading which are caused by atmospheric ducts, ionospheric reflection and refractions (Samridhi and Malhotra, 2015). The work of Armoogum (Armoogum, *et al*., 2010) underscores the importance of path loss prediction and coverage areas in radio and television broadcast system, since the wave interacts with the environment leading to attenuation of signal.

It is based on the above, that various authors have carried out studies that will ensure QoS of DTT in other parts of the world (Armoogum, *et al.,* 2010). However, there is dearth of scientific studies on DTT in Nigeria. It therefore becomes necessary for radio scientist to carry out studies on digital terrestrial television propagation curve (which is useful for predicting channel losses, coverage areas and network planning) and other factors that can enhance or degrade signal's quality with a view of improving the QoS on DTT broadcasting and networking in Nigeria.

This study investigates the propagation link which is the variability in the values of DTT signal strength with distance and the elevation of the study areas. The ultimate goal is to determine the enhancements and degradation of signal on the LOS link as a result of the elevation patterns of the study areas and as well determine the suitable receiver antenna heights for optimum signal reception.

Study Areas and the Experimental Station

Two Digital Terrestrial Broadcast Stations (DTTBS) owned by the NTA-Star Times in Akure and Katsina cities were used for this work. Table 1 presents details about the DTTBS.

Table 1: Transmission characteristic of the experimental DTTBS

Parameter	Akure DTTBS	Katsina DTTBS
Base station's geographic coordinates	Lat. 7°15' 08" N, Long. 5°07' 53" E	Lat.13° 01' 50" N Long. 7° 32' 50" E
Base station's transmitted power (kW)	2.40	2.40
Base station's frequency (MHz)/ Channel	722 / 52	530/28
Height of transmitting mast (m) A.G.L	200	200
Height of receiving antenna (m) A.G.L	1.5, and 3.0 (Variable)	1.5, and 3.0 (Variable)
Climatic Zone	Tropical Rain Forest	Sahel Savannah

METHODOLOGY

Instrumentation

A digital satlink model WS-6936 field strength meter was used for the DTT signal strength measurement by connecting the terrestrial input signal received by the Star Times UHF receiving antenna attached to a variable antenna stand to it. Whereas a Global Positioning System receiver (GPS Map 78s personal navigator) was used for the measurement of elevation, geographic coordinates and the line of sight of the various data locations from the base station. A field vehicle was used for the field campaign. Figures 1 and 2 present the digital Satlink field strength meter and the GPS used for this work.

Figure. 1: Digital field strength meter

Figure. 2: GPS Map 78s

Data Collection and analysis

Measurement of signal strength of the DTTBS in Akure and Katsina cities were carried out from the base stations along three different routes using the digital satlink field strength meter at interval of 1 km Line of

Sight (LOS). Two sets of data were obtained for the signal strength for two antenna receiver heights of 1.5 and 3.0 m for each location. This is to give room for comparison in the strength of signal received for variable heights. The line of sight from the base station was monitored using a GPS, which equally measures the location's longitude, latitude, and the elevation (above sea level). Data were collected during dry (November) and wet (June) season months for two consecutive years (2016 and 2017) for comparative studies. A field vehicle was used as a means of movement along the routes during the field work. Detail of the routes categorization is as presented in Table 2. Figures 3 and 4 present the google maps of Akure and Katsina indicating routes of measurement. Transmission parameters of the DTTBS were relatively constant throughout the period of measurement as confirmed by the records of transmission in the stations. The data obtained were used to plot the propagation curves for the signal for the two seasons and years under investigation with necessary statistical analyzes also carried out.

Table 2: Route definition for the field work

Route	Akure DTTBS	Katsina DTTBS
A	Base station towards Oda Town (0-16 km LOS)	Base station towards Batsari Town (0-15 km LOS)
B	Base station towards Ita Ogbolu (0-20 km LOS)	Base station towards Dutsinma Town (0-19 km LOS)
C	Base station towards Ilaramokin (0-12 km LOS)	Base station towards Daura (0-14 km LOS)

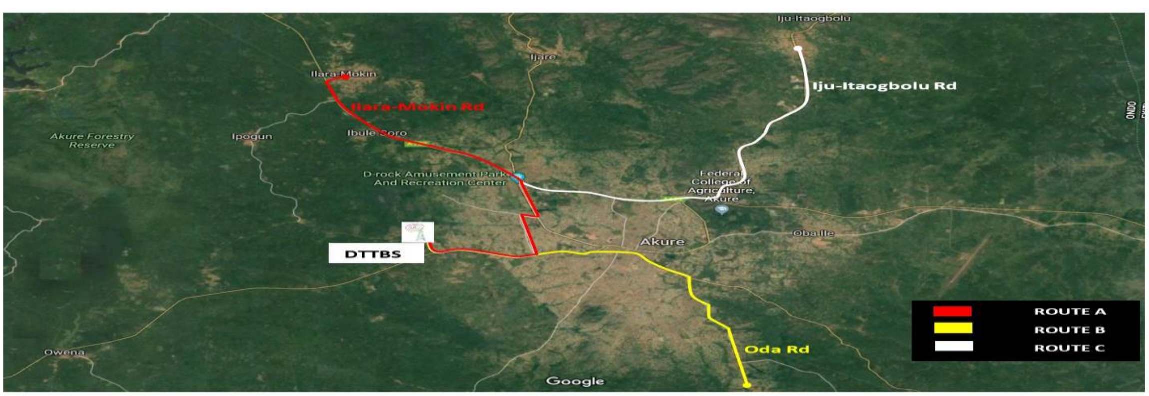


Figure 3: Google map indicating the three routes of signal Strength measurement in Akure.

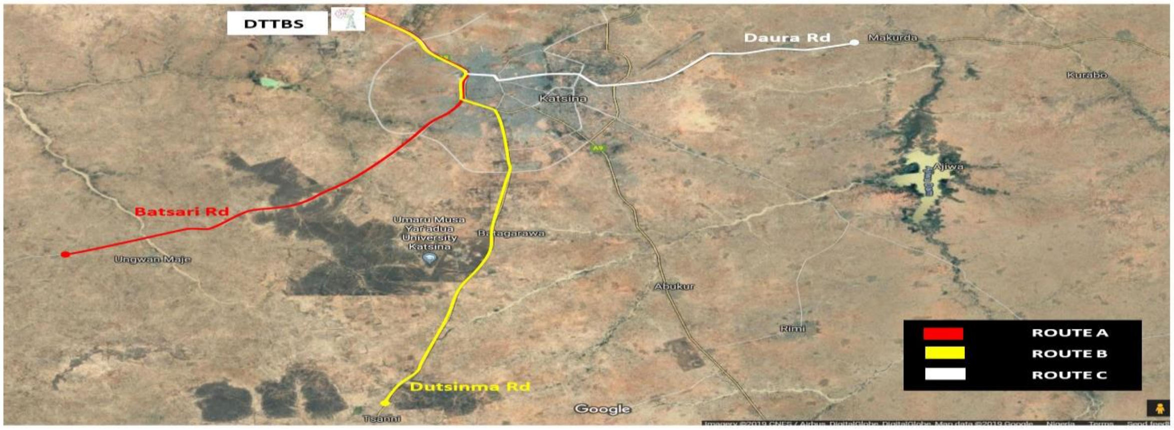
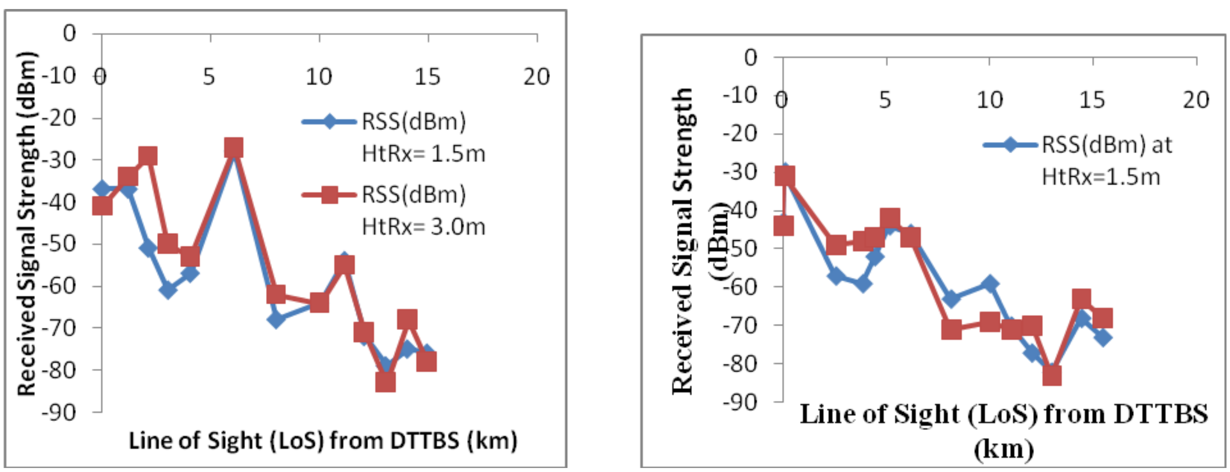


Figure 4: Google map indicating the three routes of signal strength measurement in Katsina.

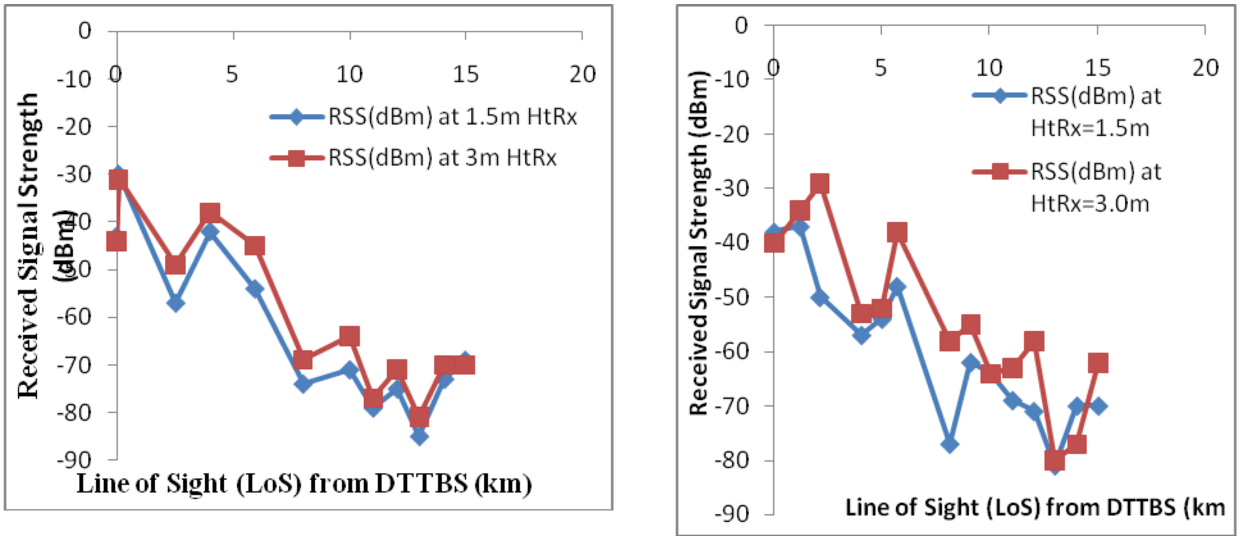
RESULTS AND DISCUSSION

In this section, typical propagation curves which is the decay of the signal strength with distance for both stations during dry and wet seasons using the two receiver antenna heights (RxHt) of 1.5 and 3.0 m along the routes of measurement are presented. For Akure DTTBS, Figures 5a and 5b present typical propagation curves during dry seasons whereas Figures 6a and 6b present the propagation curves for wet season



(a) (b)

Figure 5: (a) Typical propagation curves for two receiver antenna heights during dry season in the year 2016 for Akure DTTBS. (b) Typical propagation curves for two receiver antenna heights during dry season in 2017 for Akure DTTBS
HtRx= Height of receiver antenna

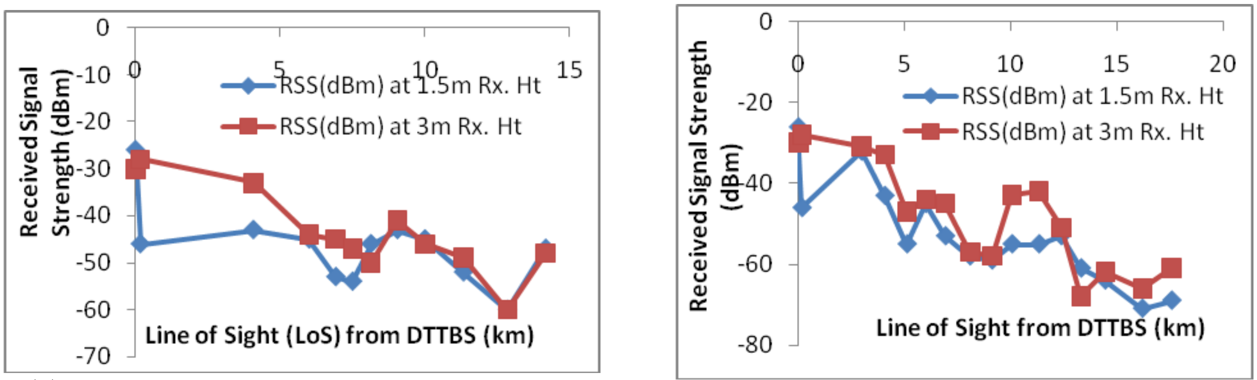


(a) (b)

Figure 6: (a) Typical propagation curves for two receiver antenna heights during wet season in the year 2016 for Akure DTTBS. (b) Typical propagation curves for two receiver antenna heights during wet season in the year 2017 for Akure DTTBS

The propagation curves (Figures 4 and 5) in the tropical rain forest zone (Akure) for the two seasons considered show that the received signal strength (RSS) decay inversely with distance. However, there were few exceptions where farther trans-receiver distances (LOS) recorded higher signal values compared to nearer locations. This can be attributed to the influences of tropospheric parameters such as elevation pattern of the study areas, meteorological parameters (humidity, precipitation, and atmospheric pressure e.t.c), terrestrial factors (trees, vegetations, hills) and surface radio refractivity. RSS was generally enhanced when receiver antenna height of 3.0 m was used in all the routes and seasons. This may be due to the fact that higher antenna minimizes losses due to multi paths effect. Signal strength enhancement attributed to higher (3.0 m) receiver antenna was more pronounced during the wet season (Figures 6a and 6b) compared to the dry seasons (Figures 5a and 5b) in Akure. This may be attributed to higher level of attenuation due to multipath during the wet season especially in the tropical rain forest zones in which the use of higher antenna height minimizes losses due to multipath.

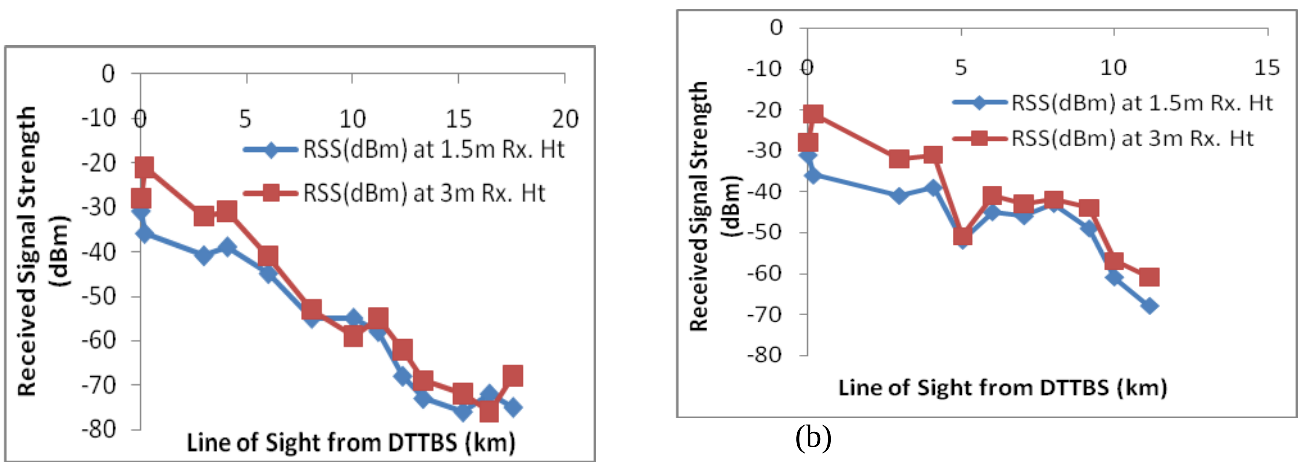
The propagation curves for the Sahel Savannah base station in Katsina are as presented. Figures 7a and 7b depict the curves for dry season whereas figures 8a and 8b depict the curves for wet season.



(a)

(b

Figure 7: (a) Typical propagation curves for two receiver antenna heights during dry season in the year 2016 for Katsina DTTBS. (b) Typical propagation curves for two receiver antenna heights during dry season in the year 2017 for Katsina DTTBS



(b)

(a)

Figure 8: (a) Typical propagation curves for two receiver antenna heights during wet season in the year 2016 for Katsina DTTBS. (b) Typical propagation curves for two receiver antenna heights during wet season in the year 2017 for Katsina DTTBS

The typical propagation curves for the routes in the Sahel Savannah (Katsina) of Nigeria and for the two seasons considered show similar trend with that of Akure but there were significant differences. Signal strength enhancement attributed to higher receiver antenna was more pronounced during the wet season compared to the dry season in Akure, the enhancement is relatively consistent for both seasons in Katsina. This can be attributed to minimal influences of terrestrial factors (like trees, vegetations, hills) and precipitation that are less prevalent in the Sahel compared to the tropical rain forest. Another finding from the propagation curves is that the received signal strength (RSS) drops to about half of its base station’s value at about 8 km Line of Sight (LOS) from the base station in Akure (figures 6 and 7) whereas it drops to about half of its base station’s value at about 10 km LOS from the base station in Katsina (figures 7 and 8). The interpretation of this is that Digital Terrestrial Television Signal suffers lesser attenuation in the Sahel compared to the tropical rainforest zone. This can be attributed to high elevation pattern, lower impact from the less dense terrestrial factors and precipitation that characterise the Sahel compared to the tropical rain forest zone of Nigeria.

CONCLUSION

Studies on the propagation links of two DTTBS in Akure and Katsina cities were carried out for both dry and wet seasons along some routes from each of the base stations. Some of the major findings are;

The RSS of the base stations decayed with distance for all the routes and seasons but was generally enhanced when higher receiving antenna height of 3.0 m was used compared to the values recorded when receiving antenna height of 1.5 m was used. In addition, RSS was more enhanced in Katsina compared to Akure despite same Effective Radiated Power (ERP) of the two transmitters. This can be attributed to higher elevation pattern, lower impact from the less dense terrestrial factors and precipitation that characterise the savannah region compared to the tropical rain forest zone of Nigeria.

From the statistical analysis on obtained data, mean values of elevation over the study areas were **357.07 m** and **523.97 m** in Akure and Katsina respectively. In addition, average values of **0.53** and **0.80** positive correlation coefficients were obtained between RSS and elevation above sea level of study locations in Akure and Katsina respectively. For subscribers within the fringe coverage of the DTTBS in Akure, (12 -20 km) and Katsina (15-20 km) LOS, it is recommended that their terrestrial receiver antenna heights should be $\geq$ **3.0 m** for optimum reception of signal especially in Akure. Star Times Nigeria is advised to increase the output power of their transmitters in the tropical rainforest zones of Nigeria to compensate for losses especially at the fringe (12 -20 km LOS from the base station) coverage areas or increase the number of transmitters within their network compared to the savannah region which recorded lower attenuation of signals. The overall findings will be useful for planning DTT links and network over the study areas.

REFERENCES

Ajewole, M.O., Oyedum, O. D. Adediji, A. T., Moses, A. S., Eichie, J. O. (2013). Spatial Variability of VHF/UHF Electric Field Strength in Niger State, Nigeria. International Journal of Digital Information and Wireless Communications, 3(3), 26 – 30.

Ajewole, M.O., Akinbolati, A., Adediji, A. T., Ojo, J. S. (2014). Precipitation Effect on the Coverage Areas of Terrestrial UHF Television Stations in Ondo State, Nigeria, International Journal of Engineering and Technology, 4(9), 524 – 535

Akinbolati, A., Ajewole, M.O., Adediji, A. T., Ojo, J. S. (2017). The Influences of Meteorological Parameters on Digital Terrestrial Television (DTT) Signal in the Tropics, International Journal of Digital Information and Wireless Communications, 7(3), 161– 172.

Akinbolati. A, O. Akinsanmi., K. R. Ekundayo. (2016). Signal Strength Variation and Propagation Profiles of UHF Radio Wave Channel in Ondo State, Nigeria, International Journal of Wireless and Microwave Technologies (IJWMT), 6(4), 12-27

Akinbolati, A., Ajewole, M.O., Adediji,A. T., Ojo, J. S. (2015). Determination and Classification of Coverage Areas of errestrial UHF Television Transmitters in Ondo State, Nigeria, International Organization of Scientific Research, Journal of Applied Physics (IOSR-JAP), 7 (4), 16 – 26.

Armoogum, V., Soyjaudah, K.M.S., Mohamudally,N., Forgarty, T. (2010). Propagation Models and their

Applications in Digital Television Broadcast Network Design and Implementation, Trends in Telecommunications Technology, Christos J Bouras (Ed.) pp165- 183

Ayekomilogbon, O. T., Famoriji, J. O., Olasoji,Y. O (**2013).** Evaluation and Modeling of UHF Radio wave Propagation in a Forested Environment, International Journal of Engineering and Innovative Technology; vol. 2 (12), pp.101-106

Bothias, L., (1987). Radio Wave Propagation, McGraw-Hill Inc. New York St. Louis and Francisca Montreal Toronto.

Broadcasting Organization of Nigeria (BON) Reports (2017)

Kenedy, G., Bernard, D (1992)**.** Electronic Communication System, McGraw-Hill/Macmillan, Singapore. 80 – 85.

Samridhi, D., Malhotra, J. (2015). Perfomance Evaluation of Channel Codes for High Data Rate Mobile Wireless System, I. J. Wireless and Microwave Technologies (IJWMT) DOI: 10.5815/ijwmt.2015.04.03., pp 24-25,