https://doi.org/10.51459/futajeet.2021.15.2.249

Journal of Engineering and Engineering Technology

PERFORMANCE OF DVB-T2 SIGNAL NETWORK IN THE DRY SEASON: A Case Study of Jos in Nigeria

Igbonoba, E. E. C. and Edeoghon, A. I.

Computer Engineering Department, University of Benin, Benin City, Nigeria

ARTICLE HISTORY

Received: 24-04-20

Accepted:17-06-21

KEYWORDS:

Signal Propagation, DVB-T2, Signal Parameters; Carrier to Noise Ratio, Signal to Noise Ratio

ABSTRACT

The perturbations arising from the poor weather conditions remain a major problem to television (TV) signal transmission in Nigeria due to signal attenuation and degradation between the transmitter and receiver stations. These atmospheric perturbations are prevalent along the signal paths. This study presents the performance of digital video broadcasting terrestrial –second generation (DVB-T2) television network in Jos, Plateau State in Nigeria, using Integrated Television Services (ITS) Limited signal (Nigeria Television Authority Signal Distribution Company). The drive test measurements methodology was adopted in measuring field strength and received signal strength parameters during the dry season. These measured parameters were used to calculate for the Carrier to Noise ratio (CNR) and Signal to Noise ratio (SNR) through empirical method. Finally, the CNR and SNR were used to evaluate the performance of DVB-T2 television network in Jos, and a comparison was made between their values in both wet and dry seasons. The result of the research shows that DVB-T2 television network in Jos had a better signal quality (performance and coverage) in the dry season compared to the raining season.

Correspondence: *igbonoba2000@live.com, isi.edeoghon@uniben.edu; +2348058234965*

1. INTRODUCTION

The DVB-T2 broadcast transmission system is designed to increase capacity, ruggedness and flexibility compared to the DVB-T system while DVB-T2 Lite is the DVB-T2 profile designed to efficiently deliver TV and radio services for mobile devices such as phones and tablets (ITU-R, 2016). This has encouraged substantial growth in the mobile communication services over the last few years (Cetin and Begum, 2016). It has become inevitable to transmit high quality and capacity broadcast network in Nigeria. Predicting coverage accuracy has become extremely important in broadcasting (Nadir *et al*., 2008). Therefore, for more accurate coverage design of modern Television broadcast networks; signal strength, received signal strength, Carrier-to-Noise Ratio (CNR) and Signal-to-Noise Ratio (SNR) measurements must be taken into consideration in order to provide an efficient and reliable coverage area with acceptable quality TV services. This research addresses the comparisons between the theoretical and the empirical propagation analysis

https://doi.org/10.51459/futajeet.2021.15.2.249

achievable with the most extensively used propagation data for digital television (DTV) broadcasting measurements recognized by the International Telecommunication Union (ITU).

The signal attenuation and degradation may be due to effects of, free space loss, refraction, diffraction, reflection, aperture-medium coupling loss and absorption but most importantly the atmospheric perturbations. These perturbations are found within terrain contours, environment (urban or rural, vegetation and foliage), propagation medium (dry or moist air), the signal paths between the transmitter (TX) and the receiver (RX), the height and location of antennas (Shalangwa and Jerome, 2010). The digital terrestrial transmission of signal on the ultra- high frequency (UHF) broadcast band is by space wave which propagates on line-of-sight (LOS) from source (Transmitter) to destination (Receiver) through the troposphere (Akinbolati *et al*., 2020). The major difference between the digital terrestrial televisions (DTTV) and analog terrestrial television (ATTV) is that digital signals are transmitted by multiplex transmitters and are radiated from the transmitting antenna while in analog system; the analog signals are transmitted through a single channel by an analog transmitter. The multiplex transmitter enables the transmission of multiple channels in a single frequency range. The digital terrestrial network comprises of several terrestrial transmitters with a specific coverage area. The coverage area of the terrestrial television are influenced by factor like; the output power of the TX, the height of transmitting and receiving antennas, terrain between the transmitter and receiver, effect of the meteorological parameters and foliage (Akinbolati *et al.,* 2016).

Since the commencement of the analog switch off (ASO) to digital switch over (DSO) in Nigeria on 30thApril, 2016 in Jos (nbc.gov.ng), the digital switch over has been partial across seven (7) states of the federation as at the time of this research work. These states are: Plateau State, Federal Capital Territory, Kaduna, Kwara, Osun, Enugu and Akwa Ibom State. The choice of Jos, Plateau State was predicated on the fact that the DSO commenced in Jos and the output of this research work shall serve as an advisory document for feature implementations in order to avert the mistakes of DSO implementation in Plateau State.

The digital terrestrial television broadcasting (DTTB) is exposed to various attenuation factors that can degrade signal before reaching its destination (Armoogum *et al*., 2010). For this simple reason, it has become expedient to investigate the propagation pattern and performance of DTTB over various climatic zones which are aimed at improving its quality of service (QoS). The attenuation of signal in ATTV may not result to total loss of signal because of its tolerant level. However, this cannot be tolerated in the DTTB where attenuation of signal below the threshold value of -116dBm leads to total loss of signal (Faruk *et al*., 2013; IEEE 802.22 Standard, 2011).

The DVB-T2 is the world's most advanced DTTB system, offering more robustness, flexibility and at least 50% more efficiency than any other DTTB systems (Lusekelo and Anael, 2014). The main goals of DVB-T2 standard is to achieve more bandwidth

https://doi.org/10.51459/futajeet.2021.15.2.249

compared to digital video broadcasting terrestrial-first generation (DVB-T), targeting high definition television (HDTV) services, improve single frequency networks (SFN), providing specific service targeting robustness, and services for fixed and portable receivers with 50% capacity throughput improvement compared to DVB-T (Kondrad *et al*., 2009)

1.1 THE DVB-T2 SYSTEM AND MODULATION

The DVB-T2 fulfilled technical functionalities mainly from DVB-T (ETSI 300 744, 2009) and the digital video broadcasting satellite-second generation (DVB-S2) (ETSI 302 307, 2009). The DVB-T2 system offers meaningfully enhanced performance in mobile channels and its coding schemes greatly outperforms the forward error correction (FEC) techniques used in DVB-T. The higher order constellation, 256- Quadrature amplitude modulation (QAM), increases the spectral efficiency and the bit-rate of DVB-T2 (Berjon-Eriz *et al*., 2011). The flexibility of DVB-T2 offers other configurable parameters that could provide numerous configuration modes, providing different levels of protection and bit-rates for DVB-T2 signals that could increase the robustness of the signal optimized data transmission capacity, and some combinations can be chosen to balance between robustness and transmission capacity. The DVB-T2 also provides mobile and pedestrian reception with standard definition, high definition and other services available. The DVB-T2 services and higher layer signaling data are transmitted in physical layer pipes (PLP) (ETSI EN 302 755, 2011). The system permits the transmission of multiple PLP at the same time, with different levels of coding, modulation, and time interleaving which permits one service for mobile reception and other service for fixed HDTV reception.

The DVB-T2 uses multiple carriers' orthogonal frequency division multiplexing (OFDM) techniques. Adding forward error correction (FEC) gave rise to coded OFDM (COFDM) which improves the robustness of transmission as presented by Lusekelo and Anael (2014). The 64-QAM and 256-QAM are the modulations used in DVB-T2 technology. Nigeria adopted 256-QAM technique, delivering a gross data rate of 8 bits per symbol per carrier.

1.2 SIGNAL PERFORMANCE PARAMETERS

In this section, the carrier to noise ratio (CNR) and signal to noise ratio (SNR) were used to evaluate the signal performance of DVB-T2 network in Jos.

1. The CNR measures the received carrier strength relative to the strength of the received noise or CNR is defined as the ratio of the relative power level to the noise level in the system bandwidth. The high CNR ratios provide enhanced quality of reception, and largely higher communications accuracy and reliability, than low CNR ratios as presented by ITU-R BT.2254 (2012). The CNR is calculated using the equation 1 and 2 (Lusekelo and Anael, 2014):-

$$\text{CNR} = \frac{P_{received}}{P_{noise}} = \frac{P_{received}}{F*K*T_0*B} \quad (1)$$

https://doi.org/10.51459/futajeet.2021.15.2.249

where;

P_{noise} is the received noise Input power

F is the received noise figure

$P_{received}$ is the minimum receiver Input power

B is the received noise bandwidth (MHz)

K is the Boltzman constant

T_o is the absolute temperature (290k)

$$P_{received}(dB) = CNR\,(dB) + F\,(dB) + 10\log_{10}B\,(MHz) - 114 \quad (2)$$

The CNR defines the robustness of transmission systems with respect to noise and interference. By extension, CNR is used to describe the signal level necessary to receiving a viable signal in noise and interference limited channels. Then, the determination of the CNR is very important for network planning as it gives a proper picture of signal carrier analysis recognition. CNR actually defines the quality of a communication channel and the threshold data for CNR for DVB-T2 is minimum 22dB and maximum 70dB as presented by Lusekelo and Anael (2014).

1. The SNR is defined as the ratio of the received signal strength over the noise strength within the frequency range of operation. The noise strength may include the noise in the atmosphere or location and other unwanted signals (interference). The signal to noise ratio is a common pointer used to assess the quality of a communication link and is measured in decibels (dB). Furthermore, SNR is calculated as the ratio of average symbol power to noise power. The noise power includes any factor that causes the symbol to differ from the ideal state position, including additive noise, distortion and inter-symbol-interference (ISI). The SNR is given as in equation 3 (Lusekelo and Anael, 2014);-

$$SNR = 10 \log \left(\frac{signal\ power}{noise\ power}\right) \quad (3)$$

$$SNR = CNR - 10 \log_{10} (m) \quad (4)$$

where:

$m = \log_2 M$ for M – QAM in DVB-T2,

M = 64 or 256

For F = 6dB and B = 7.71MHz for carrier mode 8k for 8MHz channel.

The performance of DVB-T2 signal was determined in this section using the combination of CNR and SNR calculated from the field measurements of received signal strength (RSS) in decibel milliwatts (dBm).

2. MATERIALS AND METHOD

This section presents the measurement and readings of DVT-T2 Television signal levels in different locations around Jos and its environs in Plateau State Nigeria. The measurement campaign was carried out in the dry season (November and December, 2019) to actually ascertain if rain has serious effect on DTTB signal in the area investigated. This was compared to the result obtained in the wet season in the month of July and August, 2019 with the same materials and methods applied. The locations under investigation were divided into two routes (route A and B) across the assumed coverage area of the DVB-T2 TV signals. The signal from Integrated Television

https://doi.org/10.51459/futajeet.2021.15.2.249

services (ITS) was used for the measurement campaign. The network (ITS) has operating frequency of 522MHz as allotted by National Broadcasting Commission (NBC) and is the only DVB-T2 network operator (free-to-air) in Plateau State at the time of this research work. The basic characteristics of the ITS TX is presented in Table 1.

Table 1: The ITS network parameters

S/N	Parameter	DVB-T2 Value
1	TX frequency	522MHz
2	Effective isotropic radiated power (EIRP)	62.14dBm
3	Base station location and Geographical Coordinate	Latitude: 9.89°, Longitude: 8.87°
4	Base station transmitted power (Kw)	1.3Kw
6	Transmitting antenna height (m)	107m
7	Mobile antenna height (m)	10m
8	Antenna Pattern	Horizontal – Omnidirectional

The Table 1 summarizes the basic ITS transmitter and receiver antenna parameters used in analyzing the performance of the DVB-T2 signal network in Jos and its environs. Furthermore, the map in Figure 1 presents the geographical location of the seventeen (17) Local Government Areas of the State with the signal coverage areas. The pink coloured aspect of the map represents the investigated area with signal while the un-coloured aspect represents the area without DTTB signal. The choice of Jos and its environs for the measurement campaign in Plateau State is predicated on the fact that the ITS transmitter is sited in Jos. This will further assist in the determination of the actual performance of DTTB signal in Plateau State.

The Field measurement on a drive test was adopted to measure the forty eight (48) locations on two routes (A and B) in Jos and its environs. The result of the campaign was compared to the result obtained from same route in the wet season. During the measurement exercise, DTTB signal was present in eight (8) Local Government Areas (Jos North, Jos East, Jos South, Bassa, Riyom, Barkin Ladi, Bokkos and Mangu) (route A and B, 24 locations each).

2.1 EQUIPMENT USED

To ensure high stability and relative precision using spectrum analyzer in carrying out field measurement in broadcasting, ITU recommendations on field measurement, relevant equipment and settings specified in ITU-R (2011) were followed. The measurement tool for the field test system comprise of test equipment carried in a Van and driven to test locations within the selected

https://doi.org/10.51459/futajeet.2021.15.2.249

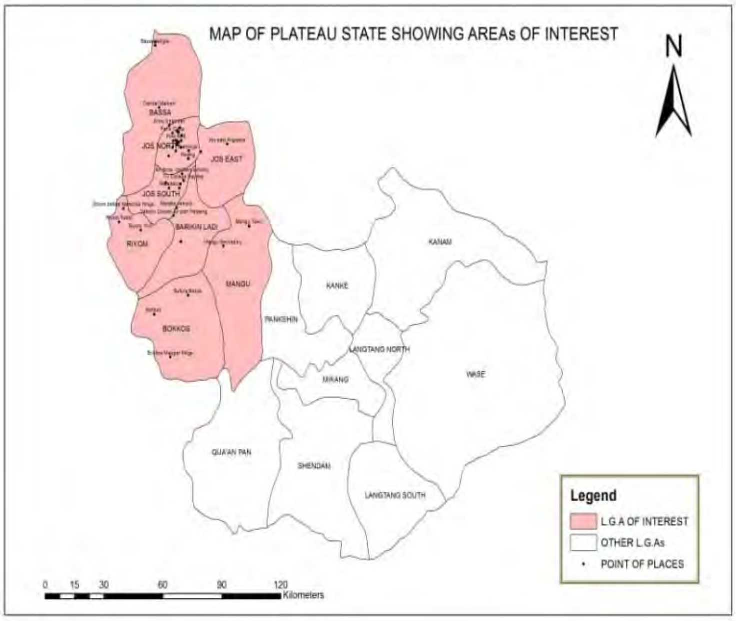

Figure 1: Geographical Map of Plateau State

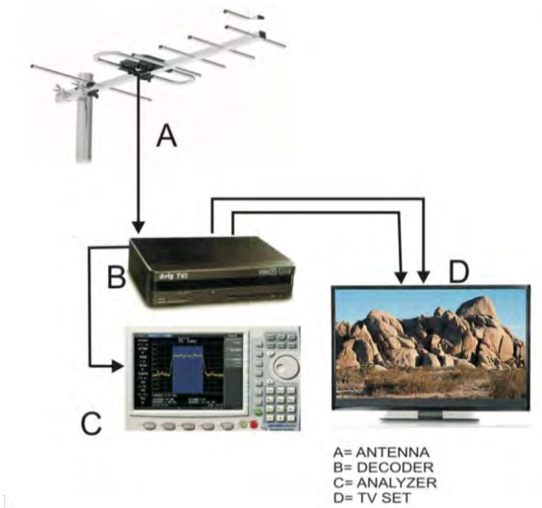

Figure 2: Equipment setup for field measurement

areas. The test equipment used as presented in Figure 2 include;-

A. A calibrated logarithmic antenna

B. Dedicated decoder (digital terrestrial receiver) capable of decoding (DVB-T2) signal

C. A deviser spectrum analyzer E8000A series

D. A Television monitor capable of displaying SDTV and HDTV (DVB-T2) signals

E. Global positioning satellite (GPS) enable smart phone

F. 75Ω, 15m RF cable and connectors

The set-up for field strength, channel power and reception quality measurement (ground and rooftop level) procedure was carried out to achieve acceptable result as laid down by ITU for frequency managers, monitoring services, and broadcasters etc.

2.2 DATA COLLECTION

The measurement of the received signal strength (RSS) of the ITS signal was carried out along two different routes (route A and B). Two sets of RSS data were obtained from the routes with ten meter (10m) height radio frequency (RF) receiver on each location. The

https://doi.org/10.51459/futajeet.2021.15.2.249

Table 2: Summary of the Computed Values for the Key Parameters Measured in the Dry Season (November and December)

S/N	Parameter	Mean Value	Standard Deviation	Highest Value	Lowest Value
1.	CNR (dB)				
	Route A	43.64	13.99	62.73	13.93
	Route B	48.39	11.66	32.63	29.43
2.	SNR (dB)				
	Route A	34.61	13.99	53.7	4.9
	Route B	39.37	11.67	57.7	20.4
3.	Received Signal Strength (dBm)				
	Route A	-55.5	14	-36.4	-85.2
	Route B	- 50.74	11.66	-36.5	-69.7

Table 3: Summary of the Computed Values for the Key Parameters Measured in the Wet Season (July and August)

S/N	Parameter	Mean Value	Standard Deviation	Highest Value	Lowest Value
1.	CNR (dB)				
	Route A	40.26	12.9	57.53	12.03
	Route B	43.05	10.94	56.93	26.73
2.	SNR (dB)				
	Route A	31.23	12.90	45.5	
	Route B	34.02	10.71	47.9	17.7
3.	RSS (dBm)				
	Route A	-58.88	12.90	-41.6	87.1
	Route B	-56.08	10.71	-42.2	72.4

geographical coordinates of the locations were logged and used as the reference point by the smart phone enable GPS receiver for the routes.

The measurement locations for the two routes were established from location 1 to location 24 and the corresponding results were obtained.

2.3 COMPUTATION (EMPIRICAL CALCULATION) AND ANALYSIS

Firstly, the CNR was obtained using equation (2),

$$P_{received}\,(dB) = CNR\,(dB) + F\,(dB) + 10 \log B\,(MHz) - 114$$

Secondly, the SNR was calculated using equation (4).

The empirical computations produce the data in Table 2.The data in Table 2 was later compared with the data obtained in the wet season as presented in Table 3.The variations recorded were used to validate the effect of

https://doi.org/10.51459/futajeet.2021.15.2.249

rain on DVB-T2 television network in Jos.

3. RESULT AND DISCUSSION

The signal quality analysis was carried out using CNR and SNR parameters. From the graphs in Figure 3-6, the relationship between the CNR and SNR is directly proportional in some locations because the increase in CNR goes with the increase in SNR. The results obtained in both routes recorded the following values (Route A highest and least value: CNR: 62.73dB and 13.93dB; SNR: 53.7dB and 4.9dB while route B, CNR: 62.63dB and 29.43dB; SNR: 57.7dB and 20.4dB). In some locations in route A, there were variations between the two parameters in the sense that instead of increase, a dip was experienced. For example, in location 12, 13 and 14, CNR and SNR fluctuated from (CNR: 51.53 - 13.93 - 37.13 dB, SNR: 42.5 - 4.9 - 28.1 dB) which shows a strong divergence as a result of signal obstructions from its line-of-sight. This dip was recorded in Du community in Jos south LGA. Predictably, increase in CNR leads to increase in SNR.

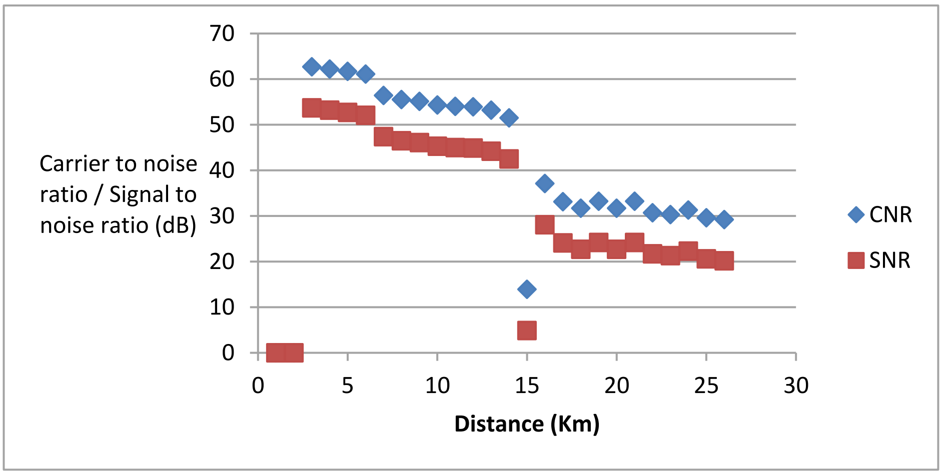

Figure 3: Plot of Carrier to Noise Ratio / Signal to Noise Ratio vs. Distance in Route A

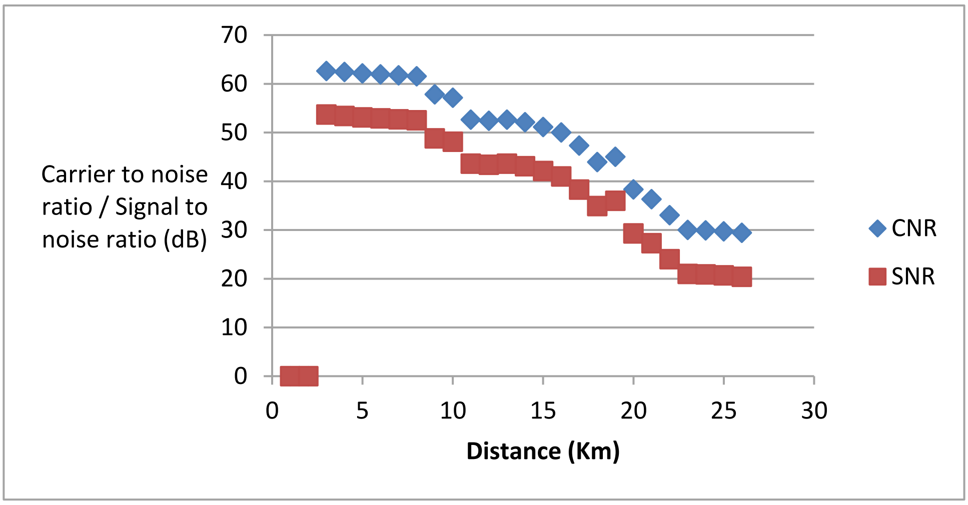

Figure 4: Plot of Carrier to Noise Ratio / Signal to Noise Ratio vs. Distance in Route B

https://doi.org/10.51459/futajeet.2021.15.2.249

The locations with very good reception or high signal levels are environments with little or no reflections with suspect to good LOS between the receiver and the digital transmitter. The SNR and CNR are found to be very high in some areas because the digital signal has high field strength and with few obstacles blocking the line-of-sight between the TX and RX. Sufficiently, the digital transmitter is serving Jos and its environs reasonably well, although some areas tend to get degraded signals due to rocky hills in the neighborhood, for example, Du community in Jos south local government area.

The signal analysis from Table 2 and 3 using the computed signal mean value present an improvement of; CNR: 3.38dB and 5.34dB on route A and B while the SNR presented an improvement of 3.38dB and 5.35dB respectively. On individual locations, the highest point in route A and B recorded an improvement of 5.2dB and 5.7dB for CNR parameter while that of SNR recorded an improvement of 5.2dB and 9.8dB respectively. This is an indication that rain has adverse effect on digital terrestrial television

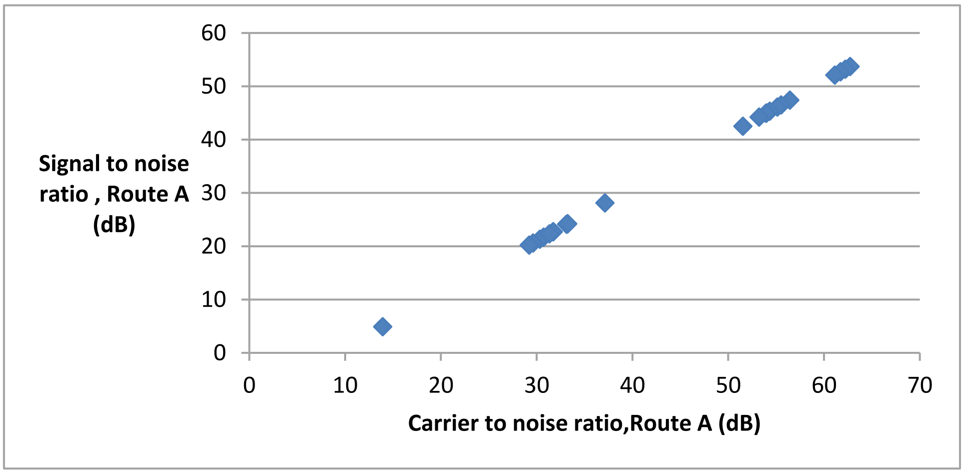

Figure 5: Plot of Signal to Noise Ratio vs. Carrier to Noise Ratio in route A

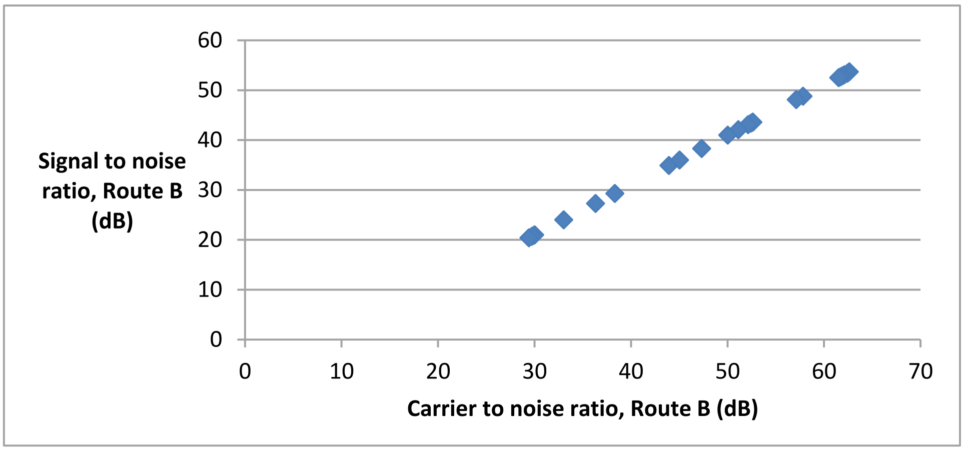

Figure 6: Plot of Signal to Noise Ratio vs. Carrier to Noise Ratio in Route B

https://doi.org/10.51459/futajeet.2021.15.2.249

signal in Jos Plateau State, Nigeria.

4. CONCLUSION

The DVB-T2 transmission network in Jos and its environs is effective within the city with high performance in the dry season. Most areas within the primary service areas had good and reliable signal (coverage and quality) apart from difficult terrains with rocky hills and mountains that experienced very poor reception. However, from the empirical analysis on the data obtained from the field, it implies that the effect of atmospheric perturbations is minimal in the dry season compared to the wet season, thus the performance of the digital terrestrial television signal in Jos is higher in the dry season.

To improve on the signal performance of DVB-T2 in difficult terrains in Jos and its environs, it would be significant to deploy direct-to-home (DTH) for effective coverage, and the signal distributor (service provider) needs to increase the transmitter capacity in order to guarantee strong and reliable signal. For better service and effective coverage of DTTB signal, an introduction of booster and repeater stations are needed to compensate for the degraded signals due to propagation path-loss caused by long distance and other prevalent factors between the transmitter and the receiver.

REFERENCES

Akinbolati, A., Ajewole, M.O., Adedeji, A.T., and Ojo, J.S. (2020). Propagation Curves and Coverage Area of Digital Terrestrial Television Base Station in the Tropical Zone. Heliyon 6, e 03599 (www.cell.com/heliyon)

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

Armoogum, V., Soyjaudah, K. M. S., Mohamudally, N., and Forgarty, T. (2010). Propagation Models and Their Applications in Digital Television Broadcast Network Design and Implementation. In Book: Bouras, Christos J. (Ed), Trends in Telecommunications Technology, pp.165 – 183

Berjon-Eriz, G., Eizmendi, I., Vélez, M., Prieto, G., Montalban, J., Arrinda, A., and De la Vega, D. (2011). Performance Evaluation Procedure for Mobile DVB-T2 Reception in Urban Environments. IEEE Conference on Broadband Multimedia Systems and Broadcasting (BMSB), BMSB2011 mm 11-89. (http://doi.10.1109/BMSB.2011.5954966)

Cetin, K., and Begum, K.E. (2016). Measurement and Evaluation of Electric Field Strength in Samsun Centre. International Journal of Applied Mathematics, Electronics and Computers, ISSN: 2147-8228, Vol. 4, Special Issue 1. (http://ijamec.atscience.org)

ETSI EN 300 744. (2009). Digital Video Broadcasting (DVB); Framing Structure, Channel Coding and Modulation for

https://doi.org/10.51459/futajeet.2021.15.2.249

Digital Terrestrial Television (DVB-T). ETSI EN 300 744 Vol.1.6.1.

ETSI EN 302 307. (2009). Digital video broadcasting: second generation framing structure, Coding and Modulation Systems for Broadcasting, Interactive Services, News Gathering and other Broadband Satellite Applications. ETSI EN 302 307, Vol.1.2.1.

ETSI EN 302 755. (2011). Digital Video Broadcasting (DVB); Frame structure channel Coding and Modulation for a Second Generation Digital Terrestrial Television Broadcasting System (DVB-T2). ETSI EN 302 755 Vol.1.2.1.

Faruk, N., Ayeni, A. A., and Adediran, A. Y. (2013). On the Study of Empirical Path-loss Model for Accurate Prediction of TV Signal for Secondary Users. Programme Electromagnetic Resources, B 49, pp. 1-5

http://www.nbc.gov.ng accessed on the 24th April, 2020

IEEE 802.22. (2011). IEEE Standard for Information Technology-Wireless Regional Network – Part 22: Cognitive Wireless RAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: Policies and Procedures for Operation in the TV Bands.

ITU-R BT.2254. (2012). Frequency and Network Planning Aspects of DVB-T2.

ITU-R. (2016). DTTB Handbook: Digital Terrestrial Television Broadcasting Networks and Systems Implementation.

ITU-R. (2011). Methods for measurements on digital broadcasting signals. Recommendation

ITU-R SM.1682-1.

Kondrad, L., Bouazizi, I., Vadakital, V. K., Hannuksela, M. M., and Gabbouj, M. (2009). Cross-Layer Optimized Transmission of H.264/SVC Streams over DVB-T2 Broadcast System. IEEE International Symposium on Broadband Multimedia Systems and Broadcasting 2009, BMSB'09. pp. 1-5.

Lusekelo, K., and Anael, S. (2014). Performance Evaluation of DVB-T2 Network and Its Optimization Recommendations: A Case of Dar Es Salaam, Tanzania. International Journal of Advanced Research in Computer Science and Software Engineering, ISSN: 2222- 1719. Volume 5. No. 7. (www.ijarcsse.com)

Nadir, Z., Elfadhil, N., and Touati, F. (2008). Path-loss Determination Using Okumura-Hata

Model and Spline Interpolation for Missing Data for Oman. Proceedings of the World Congress on Engineering 2008 London, U.K, Vol. 1.

Shalangwa, D. A., and Jerome, G. (2010). Path-loss Propagation Model for Gombi Town, Adamawa

State, Nigeria. International Journal of Computer Science and Network Security, Vol. 10, No.6, pp.186 -190 (www.semanticscholar.org)