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Nigeria Digital Terrestrial Television Broadcasting: An Evaluation of the Transmitted Signal received under different environmental features in North-Central Region

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ABSTRACT

The Government of Nigeria in the year 2016 switched from analog television broadcasting to digital terrestrial television broadcasting with the focus of providing reliable quality of television services to users. Regardless of the advantages of digital Terrestrial television system over analog television and efforts make by Nigeria Government to improve broadcasting, Signal reception is observed to be very poor. Therefore, this study aimed at monitoring, evaluating and mitigating environmental factors that cause signal degradation as well as attempting to provide solutions that will enhance the reception of signal even under severe environmental conditions. The transmitted signal of digital Terrestrial television was measured and received under different environmental features within the coverage area. The antenna radiation field was divided into four distinct regions (North-East, North-west, South-east and South-west of the transmitter) where the characteristics of the radiated wave are observed and measured starting from distance of 10km, 20km, 30km, 40km, 50km, up to 100km for each of the region. It was observed that the transmitted signal received at different distances varies depending on the physical features along the signal path. The result also shows that space loss increases with increase in distance. This study will guide DTT operators within the study area to precisely choose a site for installing the transmitting antenna for effective transmission.

Keywords - **Digital television, Environmental features, Signal Transmission, Signal Reception, and Signal quality**

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I. INTRODUCTION

Television broadcasting in Nigeria is undergoing transition from analog terrestrial transmission to digital terrestrial transmission that can convey more channels in the same bandwidth and provides more new features that analog terrestrial television cannot [7,16] . Digital Terrestrial television (DTT) delivers an attractive, low cost multi-channel service offering to a wide audience [4, 2]. In many countries including Nigeria, it is the primary means of distributing broadcast video content and it is developed as part of a multi-platform digital broadcasting strategy [12]. DTT has spectrum efficiency because it can accommodate more television programs in the same spectrum, using a multimedia interactive service that uses satellite, cable and

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terrestrial system to accommodate the broadcasting system in wide range area [9, 11, 15].

The propagation of digital television signal can be carried out through satellite, cable or terrestrial system [17]. For This study, we focused on the terrestrial system which signals do not degrade easily but where it turns out to be degraded, predominantly during transmission, it can be adjusted and restored to its original state [10, 13]. This enables the initial quality of the signal to be restored or maintained at the receiving end [19]. Transmission of DTT signal is done through the atmosphere and the signal propagates with the speed of light and as it travel from the transmitter to the receiver, it is been affected by environmental factors such as mountains, hills, tall buildings, trees among others [14]. These environmental factors at some point cause severe impairments such as reflection, fading, scattering, multipath, scintillation and attenuation of the transmitted signal [23, 30]

DTT technology also includes the concept of signal compression whereby only the amount of information required to reproduce the original signal at the receiver is transmitted [3, 29] This concept enables more programmes to be conveyed at the same time on a single frequency using the same transmitter whereas the analog technology could transmit only one programme on a single frequency and transmitter which has led to ghosting effects due to multi-path signals and Spectrum congestion [12].

In the month of April 2016, the Government of Nigeria launched the digital terrestrial television either switching from analog television to digital television transmission following the regional radio communication conference of 2006 (RRC06) and the Geneva 2006 agreement (GE06) of the international telecommunication union that mandated all countries signatory to the agreement to convert from analogue to digital broadcasting services. Regardless of the advantages of DTT system and efforts make by Nigeria Government to deliver good quality of service, DTT Signal reception in North-Central Nigeria is observed to be very bad, particularly in regions like Jos and Abuja that are characterized with mountains, hills, trees and tall buildings that often impair the propagated signal resulting to huge signal losses [8, 18] . This has triggered a lot of worries amidst the media and DTT users wanting to know the actual differences in quality of services of analog television broadcasting and that of DTT. Therefore, this study will focused on enhancing the transmission of the DTT signal as well as identifying and mitigating the environmental features responsible for poor reception of the signal within the study areas. The study will also serve as guide to DTT engineers, antenna modelers and other TV transmission equipment designers on how to optimize DTT broadcasting in North Central regions of Nigeria.

For this study, both the transmitting and receiving antennas are Isotropic that radiates and received equal power in all directions as shown in figure 1. The source transmitting power (P_t), power density (P_d) in watts per square meters at a distance R from the source is calculated by [5, 6]

$$P_d = \frac{P_t}{4\pi R^2} \qquad W/m^2 \tag{1}$$

Space loss that accounts for the loss due to the distribution of DTT energy as it propagates through free space. The power density is reduced by $1/R^2$ as the distance is increased.

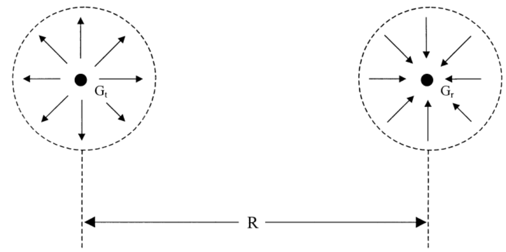

Figure 1. Isotropic antennas separated by a distance R

$$P_r = P_t\left(\frac{\lambda_0}{4\pi R}\right)^2 \tag{2}$$

$G_r = G_t = 1$ for an isotropic antenna. The term space loss is defined by

$$\text{Space loss (SL) in ratio} = \frac{P_t}{P_r} = \left(\frac{4\pi R}{\lambda_0}\right)^2 \tag{3}$$

$$\text{Where } \lambda_0 = \frac{C}{f} \tag{4}$$

$$\text{SL in Decibel (dB)} = 10log\frac{P_t}{P_r} = 20log\left(\frac{4\pi R}{\lambda_0}\right) \tag{5}$$

Where P_t is transmitting power, P_r is received power, G_t is transmitter gain, G_r is reciver gain, $C = 3 \times 10^8 m/s$, for this study frequency f = 512MHz, P_t = 1032 watts or 60.14 dBm and the distance R at various intervals are 10km, 20km, 30km, 40km, 50km, 60km, 70km, 80km, 90km, and 100km

II. LITERATURE REVIEW

Evaluation of digital video broadcasting-terrestrial second generation (DVB-T2) television signal quality in Jos by [11] stated that delivery of quality television signal remains a problem in Nigeria due to signal attenuation and degradation between the transmitter and receiver antennas which is mostly as a result of environmental and atmospheric parameters along the signal paths. They adopted Simple field measurement in measuring field strength and channel power parameters and the parameters were used to calculate signal-to-noise ratio (SNR). Their result shows that DVB-T2 transmission transmitter has almost the same reach with the analog transmission but with less transmitting power due to the lower reception signal level. High rocky hills were observed to be causing signal obstructions in communities like Du with very low signal due to its location [27, 28].

Quality of service of DTT system in Nigeria was investigated by [4] within the Ibadan metropolis, the transmitted power and altitude were measured within 40km radius of the coverage area. The grouped the city into six different zones for proper signal testing and efficient data collation. The effects of distance and altitude were analysed and was observed that there is a direct relationship between power level and altitude [24].

Modelling of radiofrequency intensities from digital terrestrial television broadcasting transmitter in Kampala metropolitan Uganda was conducted by [25, 26] Performance evaluation of the different path loss propagation models and predicting the one most suitable for Kampala metropolitan was done by comparing the path loss model values with the measured field Reference Signal Received Power (RSRP) values. The RSRP of the DTT broadcasting transmitter were measured at operating frequencies of 526 MHz, 638 MHz, 730 MHz and 766 MHz. On comparing the

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measured path loss values with the various path loss prediction model values, results showed that Egli and Davidson models are the most accurate and reliable path loss prediction models for the distribution of DTT.

III. RESEARCH METHODOLOGY

Experimental Site: The study was carried out in the cities of Jos (9.9565° N, 8.8583° E), Abuja (9.0765^{0}N, 7.3986^{0}E), and Ilorin (8.537^0 N, 4.544^0 E) North-Central Nigeria. North Central Nigeria covers latitude 70 00' to110 30' North of the equator and longitude 40 00' to 110 00' East of the Greenwich meridian. It enjoys the tropical continental climate characterized by wet and dry seasons. Wet season is synonymous to planting season since agriculture in the area is rain-fed. Mean annual rainfall ranges between 1,200mm and 1500mm while temperature is high almost throughout the year except during harmattan period which begins in November and lasts until February. The weather is cold and dry during the period coupled with hazy atmosphere and dust particles flowing around. The vegetation of the North Central Nigeria cut across the three savannah belts (Guinea, Sudan and Sahel). Most of the high plains are more than 600 metres above sea level, but some of the individual hills rise to over 1200 metres [1, 20, 21, 22].

Experimental Setup and Data Collection: The equipment used to carry out this study includes network analyzer, USB data logger, television set, DTT decoder, Radio frequency power meter, Coaxial cable port connector and connecting. Data were collected based on the setup in figure 2 and DTT transmission parameters as contain in Table 1. The DTT transmitter used is an isotopic antenna that radiates equal power in all directions. Therefore, from the transmitting antenna, the antenna radiation field is divided into distinct regions (North-East, North-west, South-east and South-west of the transmitter) where the characteristics of the radiated wave are observed and measured starting from distance of 10km, 20km, 30km, 40km, up to 100km for each of the region.

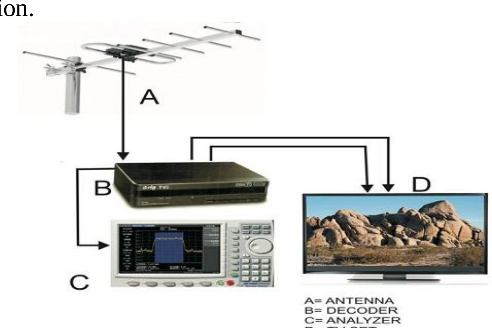

Figure 2: Experimental Setup for Measuring and Monitoring DTT Signal

Table 1: Transmission Parameters

	Jos Station	Abuja Station	Ilorin State
Latitude	9^{o}53`47.50``N	9^{o}4`20.15``E	8^{o}25`55.37``N
Longitude	8^{o}51`29.99``E	7^{o}29`28.68``E	4^{o}36`26.88``E
Antenna Model	Moyano My-PDP500	Moyano My-PDP500	Moyano My-PDP500
Antenna Type	Omni	Omni	Omni
Station Altitude (m)	1220	360	307
Transmit power (dBm)	60.14	63.98	63.98
Frequency (MHz)	512	512	512
Antenna Gain (dBi)	12	12	12
Bandwidth (MHz)	8	8	8
Antenna height (m)	130	106	107

IV. RESULT AND DISCUSSIONS

Table 2 presents the estimated Space loss and Measured received power for Jos Station within the coverage area that was divided into four regions either North-West (N/W) of the Transmitter (Tx), North-East (N/E) of the transmitter, South-West (S/W) of the transmitter and South-East (S/E) of the transmitter. Received power was measured from 10 km up to 100km. At 20km from the transmitter, it was observed that the received power varies from -65.01dBm for North-East, -65.38dBm for North-West, -64.87dBm for South-west and -63.58dBm for South-east. This shows how received power varies depending on the physical features along the signal path. The result also shows that space loss increases with increase in distance. Figure 3 shows the decrease in transmitted power received for Jos Station as the distance increases. Received power for Abuja station is presented in table 3. At distance close to the transmitting antenna either 10km, -62.98dBm was obtained at North-west, -61.63dBm for North-east, -62.08dBm for South-west and -62.49dBm for South-east regions of the transmitter. The received power obtained at 10km is much higher than the power received at 100km which has -91.63dBm for North-west, -89.43dBm for North-east, -90.20dBm for South-west and -93.41dBm for South-east. This clearly shows that distance and topography of the region have great impact on the transmitted DTT signal as well as increased in distance as shown in figure 4. Table 4 presents DTT Received power and Space loss Measured under for Ilorin Station. It was observed that the received power at far field regions either from 50km to 100km reduces compared to regions close to the transmitting antenna. As it can be seen in figure 5, the received power dropped as the distance from the transmitting antenna is increase.

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Table 2: Estimated Space loss and Measured received power for Jos Station

Distance (km)	Space Loss (dB)	Measured Received Power (dBm)			
		N/W of Tx	N/E of Tx	S/W of Tx	S/E of Tx
10	106.62	-62.98	-61.63	-62.08	-62.49
20	112.64	-65.38	-62.01	-64.87	-63.58
30	116.17	-67.35	-64.04	-66.68	-65.57
40	118.66	-68.43	-64.92	-69.30	-70.55
50	120.60	-70.01	-66.05	-71.09	-73.49
60	122.19	-71.84	-69.28	-72.76	-75.10
70	123.52	-82.73	-72.60	-75.38	-81.11
80	124.68	-86.11	-79.11	-79.55	-83.50
90	125.71	-88.64	-85.62	-86.37	-89.92
100	126.62	-91.63	-89.43	-90.20	-93.41

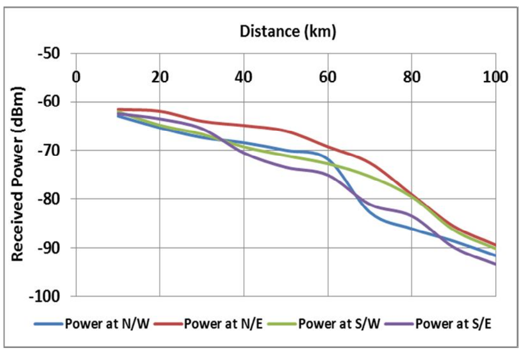

Figure 3: Measured received power with distance for Jos Station

Table 3: Estimated Space loss and Measured received power for Abuja Station

Distance (km)	Space Loss (dB)	Measured Received Power (dBm)			
		N/W of Tx	N/E of Tx	S/W of Tx	S/E of Tx
10	106.62	-62.98	-61.63	-62.08	-62.49
20	112.64	-65.38	-62.01	-64.87	-63.58
30	116.17	-67.35	-64.04	-66.68	-65.57
40	118.66	-68.43	-64.92	-69.3	-70.55
50	120.60	-70.01	-66.05	-71.09	-73.49
60	122.19	-71.84	-69.28	-72.76	-75.1
70	123.52	-82.73	-72.6	-75.38	-81.11
80	124.68	-86.11	-79.11	-79.55	-83.5
90	125.71	-88.64	-85.62	-86.37	-89.92
100	126.62	-91.63	-89.43	-90.2	-93.41

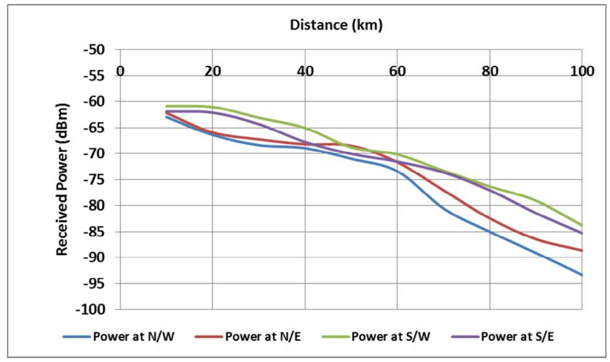

Figure 4: Measured received power with distance for Abuja Station

Table 4: Estimated Space loss and Measured received power for Ilorin Station

Distance (km)	Space Loss (dB)	Measured Received Power (dBm)			
		N/W of Tx	N/E of Tx	S/W of Tx	S/E of Tx
10	106.76	-60.98	-61.77	-62.42	-61.62
20	112.78	-61.83	-62.01	-63.71	-62.78
30	116.30	-63.01	-64.65	-64.99	-64.11
40	118.80	-65.04	-66.38	-65.04	-66.92
50	120.74	-68.79	-69.04	-66.75	-67.00
60	122.32	-71.06	-70.32	-68.92	-69.61
70	123.66	-76.29	-73.55	-71.62	-72.43
80	124.82	-81.40	-77.11	-73.00	-74.01
90	125.84	-83.52	-81.73	-76.82	-77.92
100	126.76	-87.93	-85.06	-79.36	-80.49

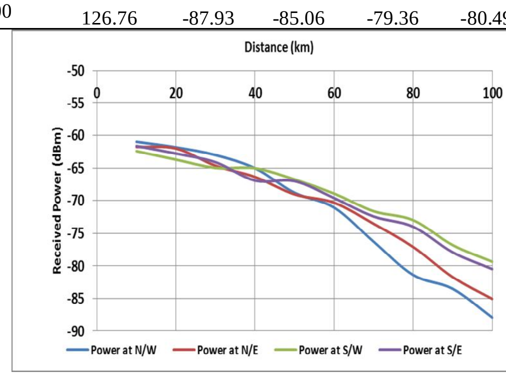

Figure 5: Measured received power with distance for Ilorin Station

V. CONCLUSION

The transmitted Power of Nigeria digital Terrestrial television was evaluated under different environmental features within the coverage area. The antenna radiation field was divided into four distinct regions (North-East, North-west, South-east and South-west of the transmitter) where the characteristics of the radiated wave are observed and measured starting from distance of 10km, 20km, 30km, 40km, 50km, up to 100km for each of the region. It was observed that the transmitted power received at different distances varies depending on the physical features along the signal path. The result also shows that space loss increases with increase in distance. It was observed that the location where the transmitting antennas where installed contribute to the poor signal reception. This study will guide DTT operators within the study area to precisely choose a site for installing the transmitting antenna for effective transmission.

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