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Evaluation and Analysis of Digital Terrestrial Television Signal in Port Harcourt and its Environs

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ABSTRACT

This dissertation work presents an evaluation and analysis of Digital Terrestrial Television (DTTV) in Port Harcourt and its environs using GOTV(Get out the vote) as a case study. The significance of this research work is to investigate the cause of degradation / weak GOTV signal in Port Harcourt and its environs, to highlight factors responsible for DTTV loss of signal as signal is been propagated from GOTV Transmitter station (one point) to receiver antenna of a subscriber (another point) and to advise on possible practice to improve transmission within Port Harcourt and its environs. The materials used for this research work includes GOTV Transmitter station, Signal Analysis Meter (DS2400T DVB-T2), Google earth, Google map, Antenna, coaxial cable, Pole etc. Ninety-six (96) points due North, South, East. West, North-East, North-West, South-East, South-West with a separation distance of five hundred meters (500M) at an angle of forty-five degree, landmarks was noted asmeasurement points, using Signal Analysis Meter (DS2400T DVB-T2) as a measuring device, results of the measurements were tabulated and graphs plotted, it was apparent that GOTV signal is better close to the transmitter station and gets degraded/weak away from the transmitter as displayed in North-East direction (Series 6) where the signal strength was good at 54.9 near the transmitter and degraded to 29.1 at a separation distance of 4000M,At AGIP, RUMUEME PHC due to topography and man-made structures like tall buildings, bridges, etc At North-West (Series7) the signal strength was 46 (500M) with elevation of 3M after covering 2500M with elevation of 14M the signal strength improved to 50.1 this was because of highland area at this point in view of the elevation height and it remained stable as the line of sight is free of blockade and the topography is to the advantage of the signal strength in this case, Also at South-East direction (Series 8) was a peculiar case where the signal was high (51.1) and rose to 51.7 due to highland and remained stable as a result of uniform level building (AMADI CREEK ESTATE) and good line of sight relatively free of loss from high-rise buildings, observation was that after a high-rise building, high-land, or low-land area in view of topography GOTV signal drops implying that the signal has suffered loss or degradation which may be interpreted as reflection, refraction, diffraction etc. Results suggest that fifty (50) and above signal strength is good and after high-rise buildings, high-land, low-land (topography) the signal may be degraded / weak.

Key words: GOTV, DTTV, Terrestrial television antenna, degradation/weak Signal, Transmitter Station

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INTRODUCTION

The deployment of Digital technology in broadcasting has transformed and revolutionized the traditional analogue approach to broadcasting. Digital broadcasting is a broadcast technology based on the transmission of audiovisual media information by bitstreams. By introducing Digital terrestrial television (DTTV) services, all stakeholders including broadcasters, viewers and regulators will benefit immensely because of increased spectrum and power efficiency, resistance to channel distortions, additional data services, flexibility in quality of programmes, greater choice of the channel due to compression technology and ability to implement Single Frequency Networks (SFN) of DTTV over Analogue Television ATV [1]. The first Orthogonal Frequency Division Multiplexing (OFDM) based system for digital modulation of propagation in the early 90's was the Digital Video Broadcasting Television (DVB-T) [2]. A digital terrestrial TV is an improvement to analogue systems, whose robustness of modulation eliminates the limitations and shortcomings met by the DVB Consortium and standardized by the European Telecommunication Standard Institute

(ETSI) [2]. Over time research and observation has proved that reception of digital signal varies from point to point and place to place and the closer your antenna is to the transmitter station while maintaining line of sight the better the signal reception, as a result this has triggered consumers concern to do business and patronize digital television with better reception as compared to the other. This project work seeks to evaluate and analyze problems associated with GOTV transmission in Port Harcourt and its environs and use the result to suggest and recommend possible improvement methods.

The terrestrial digital compression technology allows many channels to be broadcasted with the same amount of spectrum used by one analogue channel and receiving of digital signals on conversional television aerial by conversion into analogue by a set-top box (STB) or viewed with integrated digital television set (IDTV). Digital Terrestrial Television is the transmission of digital television signals from a ground-based transmitter operating in the UHF or VHF band which is radiated as radio waves and are received using a UHF or VHF antenna. Digital television transmission is the new wave of broadcasting and the future of television broadcasting [3].GOTV is entirely terrestrial, Terrestrial television is a type of television broadcasting in which the television signal is transmitted by radio waves from the terrestrial (Earth-based) transmitter of a television station to a TV receiver having an antenna. Television signals can be broadcast through a transmitter, a large structure that sends audio and video signals to people's homes. You receive these signals through an aerial which, connected with a cable, brings that signal to your TV set and changes it into an image. While DSTV is satellite based, GOTV is terrestrial based. The main advantage GOTV has over DSTV is that it does not require a satellite dish, which means there is zero cost of installation. It is very easy to install and can be used with any TV antenna to further strengthen the GOTV-DTV signals [4].

GOTV, the country's leading digital terrestrial television service, the service already operates on the digital platform and has been rolled out in about 50 cities across 26 states in the country, GOTV adopted the most modern digital video broadcast technology, DVB-T2, which is a considerable upgrade on the first generation and now discarded DVB-T systems deployed by the earliest adopters of digital broadcast technology [4].GOTV coverage service is deployed through television masts and accessible only in locations with GOTV transmitter coverage. Currently GOTV is available in the following cities in Nigeria and in some cases their environs: Lagos, Enugu, Ibadan, Abeokuta, Benin City Owerri, Akwa Ibom, and Port Harcourt.GOTV signal strength of fifty (50) and above is considered good in the cities in Nigeria while Thirty (30) and below is considered weak or degraded.GOTV signal in Port Harcourt and its environs suffer degradation/loss as signal is been propagated from transmitting station (one point) to the receiver of a GOTV signal (another point) this could be due to topography of the area and obstructed line of sight by man-made structures like high-rise building, Bridges, Towers and vegetation this study will monitor GOTV Transmitters signal and note points where signal experience degrade and the cause of degradation of signal and to justify reasons of stability/weakness of signal in each area.

DTTV-SINGLE FREQUENCY NETWORK (SFN) TRANSMISSION MODEL

The DTTV transmission-based DVB-T2 standard for SFN, the received signal from several transmitter with same Guard Interval, GI time. The transmission channel of DTTV transmission loss due to the multipath channel, Doppler effect, and phase shift. (Promwong *et al.*, 2020). The received signal is presented in equation 1

$$\mathrm{P_r}[dB] = EIRP + G_\mathrm{r} - L_\mathrm{f} \tag{1}$$

Where P_r is the received signal power, L_{fs} is the free space path loss in DTTV-SFN transmission, $G_r$is the receiver gain, and the Effective Isotropic Radiated Power, EIRP of the DTTV transmission for SFN is calculated by

$$EIRP = P_t + G_t \tag{2}$$

$$\mathrm{P_r}[dB] = P_t + G_t + G_\mathrm{r} - L_{FS} \tag{3}$$

Where P_t is the transmitted signal power, G_t is the transmitter antenna gain.

The modulation error ratio is a useful parameter for evaluating the error of digital modulation in DTTV transmission for SFN. The error vector from the interference in a constellation points are used to calculate the modulation error ratio as described below.

$$\mathrm{MER_{rms}}\,[\mathrm{dB}] = 20\left[\frac{\sqrt{\frac{1}{\mathrm{N}}\sum_{\mathrm{n}=0}^{\mathrm{N}-1}(|\mathrm{error\ \_vector}\ |)^2}}{\mathrm{U_{rms}}}\right] \tag{4}$$

Where U_{rms} is the root means square of QAM signal. The DTTV transmission-based DVB-T2 standard for SFN loss is analyzed by using the UHF propagation free space loss formula which is described in (4), Where L_f[dB] is the free space loss.

$$L_\mathrm{f}s[dB] = 20log_{10}f + 20log_{10}d + 32.4 \tag{5}$$

$$L_\mathrm{f}s = 32.4 + 10log_{10}\left[\frac{(h_{tx} - h_\mathrm{rx})^2}{1e^6} + (d)^2\right] + 20log(f) \tag{6}$$

$$\mathrm{P_r}[dB] = EIRP + G_\mathrm{r} - \left(32.4 + 10log_{10}\left[\frac{(h_{tx} - h_\mathrm{rx})^2}{1e^6} + (d)^2\right] + 20log(f)\right) \tag{7}$$

Where htx and hrx are the height of the transmitter (Tx) and receiver (Rx) respectively and are expressed in m, *d* is the distance between the Tx and Rx and is expressed in km, *f* is the frequency and is expressed in MHz.

MATERIALS AND METHODS

Materials

The materials used for this research work includes GOTV Transmitter station, Signal Analysis Meter (DS2400T DVB-T2), Google earth, Google map, Antenna, coaxial cable, Pole etc. Ninety-six (96) points due North, South, East. West, North-East, North-West, South-East, South-West with a separation distance of five hundred meters (500M) at an angle of forty-five degree, landmarks was noted as measurement points, using Signal Analysis Meter (DS2400T DVB-T2) as a measuring device as shown in Figure 1.

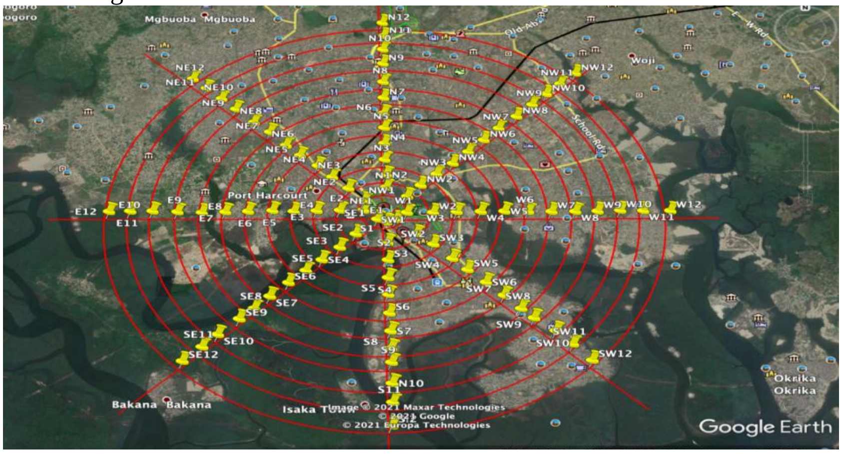


Fig. 1 Field measuring points in Port Harcourt

With improved features digital terrestrial television broadcasting offers better services compared to the existing analog broadcasting, though there are numerous positives from the deployment of digital terrestrial television broadcasting, its challenges also pose a threat to its operations as investigated in this paper.

Method

The Terrestrial Level Meter (DS2400T DVB-T2) was connected to the antenna using a coaxial cable at the RF interface, the digital display makes it easy to see and record measurement results from the LCD (Liquid crystal display), while the keyboard made it easy to input data and choose functions, one person holding the meter and the other holding the antenna fixed to a pole and raising it above his head level (height of receiver equals human height plus antenna length).The measurement was carried out at different locations (measuring GOTV signal behavior) in Port Harcourt city and its environs at over ninety measurement points away from the GOTV Transmitter station as shown in Figure 2.

Fig. 2 Field measurement in Port Harcourt

There are three soft keys (F1, F2 and F3) located under the screen. They are used to access the functions represented by the icons displayed on the bottom of the screen like ENTER, CHANNEL INFO, SAVE, REFRESH etc.

Character / Digit Input. The numeric keypad is used to input values like the required frequency (in this case 490MHz) for measurement. Press the number buttons to enter the desired value directly. Then press ENTER (F1) key to enter the value into the DS2400T meter.

DS2400T is the right meter for this research work because it can measure POWER, MER and BER simultaneously. As shown in figure 3 below, the signal strength can be good if close to the transmitter, good line of sight and free of blockade depending on the location, the elevation is also a key factor because good elevation can improve the line of sight or even overcome a blockade to the advantage of the receiver antenna. It is worth noting that sometimes the signal may not be stable because of intermittent loss or gain in signal strength, If the signal is fluctuating between two measurement the average will be recorded.

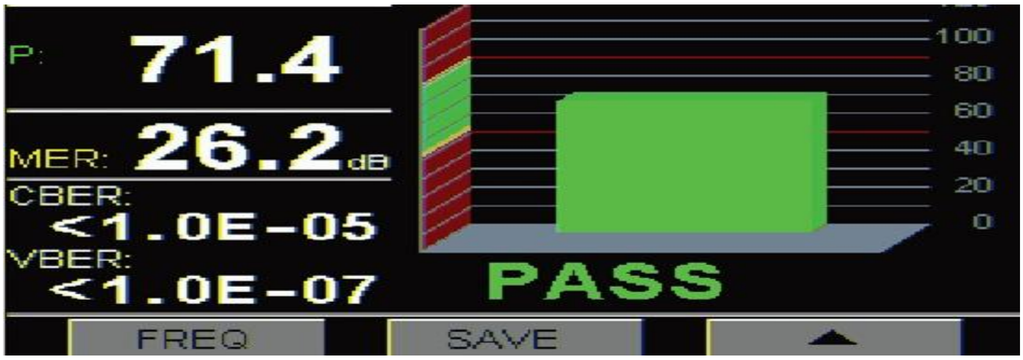


Fig. 3 Display of a good, measured signal power, MER and BER

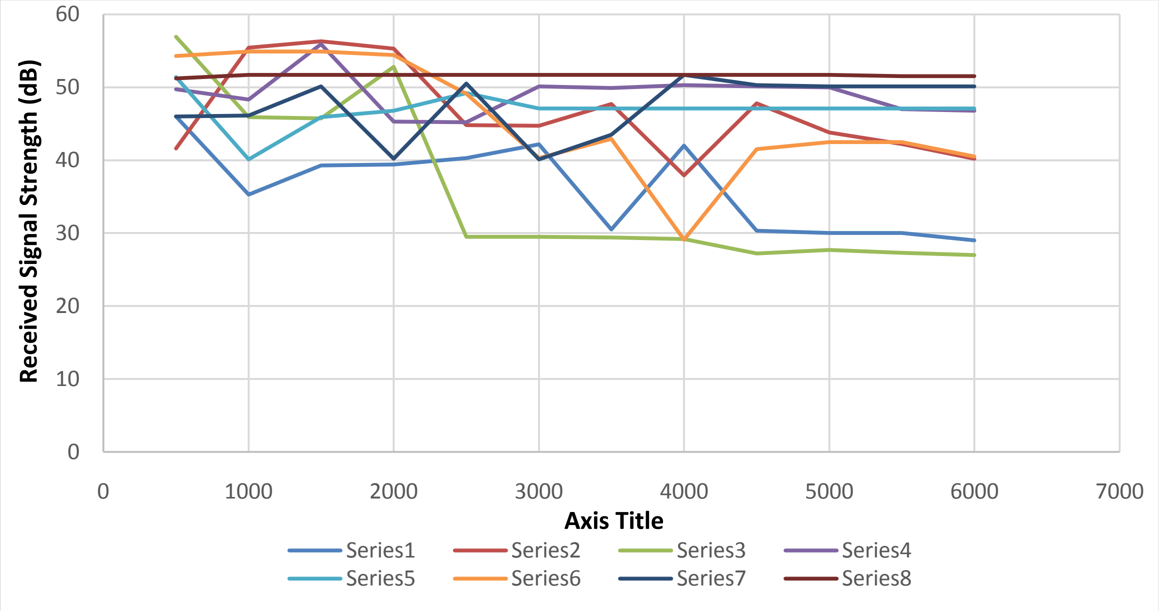
RESULTS AND DISCUSSION

To analyze the received signal power mathematically, three very important parameters were considered, the parameters are the transmitter power, the antenna gain, and the free space path loss (attenuation) in DTTV-SFN transmission and the results of the measured power, calculated power and the free space path loss in the Northern direction is shown in table 1.

Table -1 Table analyses of measured power, calculated power, and free space path loss North direction

S/N	LOCATION COORDINATES	TAG	DISTANCE FROM TRANSMITTER (m)	SIGNAL STRENGHT(POWER)	MER (dB)	CBER	LBER	Calculated Power (dB)	Free space path loss
1	4 47' 18.61"N 7 00'24.02"E	N1	500	-46	1.8	6.3E- 02	LBER 2.7E- 04	-2.5	80.2
2	4 47' 34.67"N 7 00'24.01"E	N2	1000	-35.3	1.8	6.50E-02	LBER 2.7E- 04	-8.5	86.2
3	4 48' 50.80"N 7 00'24.20"E	N3	1500	-39.3	1.3	5.8E - 02	LBER 2.6E- 04	-12	89.7
4	4 48' 07.05"N 7 00'24.40"E	N4	2000	-39.4	1.2	6.6- 02	LBER 2.7E- 04	-14.5	92.2
5	4 48' 23.63"N 7 00'24.39"E	N5	2500	-40.3	1.4	4.3E- 02	LBER 2.3E - 04	-16.5	94.2
6	4 48' 39.58"N 7 00'24.38"E	N6	3000	-42.2	1.4	4.8E- 02	LBER 2.3E- 04	-18	95.7
7	4 48' 55.77"N 7 00'24.16"E	N7	3500	-30.5	1.4	9.1E- 02	LBER 2.7E-04	-19.4	97.1
8	4 49' 12.00"N 7 00'24.15"E	N8	4000	-42	1.4	6.3E- 02	LBER 2.7E- 04	-20.5	98.2
9	4 49' 31.26"N 7 00' 14.92E	N9	4500	-30.3	1.4	9.0E- 02	LBER 2.7E-04	-21.6	99.3
10	4 49' 45.60"N 7 00' 14.89E	N10	5000	-30	1.4	9.0E- 02	LBER 2.7E-04	-22.5	100.2
11	4 49' 59.01"N 7 00' 16.78E	N11	5500	-30	1.4	9.0E- 02	LBER 2.7E-04	-23.3	101
12	4 50' 17.22"N 7 00' 17.70E	N12	6000	-29	1.4	8.8E- 02	LBER 2.7E-04	-24.1	101.8

The results are related to an actual location in the different areas of consideration. The floor plans include different conditions (different power imbalance and different amount of overlay of the radio channels). Service availability of both systems is verified again by measurements. The resulting statistics help us to better understand the effect of achievable system performance under different reception situations considering real transmission conditions. The Received Signal Strength (Power) in all regions of the Transmitter is shown in figure 4.



Distance

Fig. 4 Eight (8) Directions Graphical Analysis of GOTV Signal

The findings of this study with the help of the above graph clearly explain what happens to GOTV signal as it travels from one point to another, firstly the Northern direction relative to the transmitter is known in figure 4 as (Series1) with a ground elevation of 9M and initial signal strength of 46 dropped to 35 at exactly 1000M away from the transmitter with a ground elevation of 3M, this is low land area as compared to the initial 9M elevation suggest the reason for loss of signal /degradation as a result of blocked line of sight, it rose to 39.3 at 1500M with an elevation of 13M, no doubt the highland and an improved line of sight was the reason for the increase in signal level.

Towards the South (Series2) the signal increased from 500M separation distance from the transmitter with 10m elevation from 41.6 to 55.4 at 1000M separation distance with 4M elevation and 56.3 at 1500M separation distance with 0M elevation reason being that the line of sight was clear from the later positions as against the initial position that the signal suffered loss/degradation due to blockade from tall buildings hence, poor line of sight.

In the East (Series 3) direction GOTV signal of 56.9 close to the transmitter at a separation distance of 500M with 6M elevation degraded to 29.5 signal strength at a separation distance of 1500M along Aggrey road in Port Harcourt town even with a higher elevation of 7M because of high-rise building (SPAR), Government house and state secretariat building. The signal strength moving in the West direction (Series 4) was 49.7 at 500M away from the transmitter with an elevation of 11M and improved to 55.9 at 1500M away with a lower 0M elevation because of clear/better line of sight free from blockade and remained relatively stable. At South-West direction (Series 5) signal strength was 51.4 at 500M with 11M elevation around SPAR near the transmitter and degraded to 47.1 after a reasonable distance of 3000M with 8M elevation and remained stable at AMADI CREEK estate due to good line of sight and low levelbuildings despite the fluctuating elevation, while in North-East direction (Series 6) the signal strength was good at 54.9 near the transmitter station and degraded to 29.1 at a separation distance of 4000M (AGIP, RUMUEME, PHC) due to topography and man-made structures like tall buildings , bridges etc.

At North-West direction (Series 7) the signal strength was 46 (500M) with elevation of 3M after covering 2500M with elevation of 14M the signal strength improved to 50.1 this was because of highland area at this point in view of the elevation height and it remained stable as the line of sight is free of blockade and the topography is to the advantage of the signal strength.

South-East direction (Series 8) was a peculiar case where the signal was high (51.2) close to The Transmitter and rose to 51.7 and remained stable, this was a special case at AMADI CREEK ESTATE, same level buildings good line of sight relatively free of loss from high-rise building, high-land / low-land, vegetation etc

CONCLUSION

This paper has demonstrated how GOTV signal was monitored, evaluation and analysis result was recorded, In view of the above discussions, it is obvious that GOTV signal is strong and good close to the GOTV transmitter station with a clear and unobstructed line of sight and as signal travel from one point to another it suffers degradation/loss which is subject to the terrain / topography of the area in question, also man-made structures like high-rise buildings, Bridges, Towers and vegetation affects signals as a result of reflection, diffraction, refraction etc.

Through this research work as well as from experience we discovered that as GOTV signal travels in each/different directions their behavior varies depending on factors such as topography and man-made structures which effects signal strength and signal may be good or bad depending on the locations.

Finally, this finding has addressed in detail the research objective approaches employed in this study and pointed out the potential limitation in the evaluation and analysis of GOTV in Port Harcourt and it environ, it is apparent that at five hundred meters (6000M) away or more signal is good and sometimes bad (not stable) depending on the conditions. It is obvious a measurement cannot be suitable for every location/area hence the need to measure and check the point of measurement (as regards topography, vegetation, man-made structures).

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