Determination of Causes and Effect of Signal Interferences in Television Stations in Nigeria

Kamalu U.A., Anyakora N.N and Dike J.N.

Abstract— This work is on determination of causes and effect of signal interferences in television stations in Nigeria. It aims at identifying the existence of interference between two nearby Television stations. It also identifies the level, the causes and the effects of such interference. To achieve this, experiments were carried out within the six geopolitical zones of the country. The experiments proved the existence of interference and the simulations carried out using existing ITU mathematical models gave the interference signal level for each station considered. The values obtained were simulated using Mat Lab and various graphs were plotted confirming the existence and level of interference.

Keyword — Antenna, Broadcast, Management, Radio, Signal, Interference, Spectrum, Television

1 Introduction

Interference occurs when two waves occupy the same area of space at the same time. The occurrence of interference could be prevented, or at least minimized, by preventing two or more electromagnetic waves from simultaneously occupying the same point in space. This could be achieved by separating the waves (or the systems that transmit or receive them) either by time, frequency, space, signal (strength, intensity, etc.), or any combination of these. This makes the allocation/assignment of different frequencies (or wave bands) to different applications a primary function of spectrum planning and management (Atanda, 2001). To underscore its importance, frequency allocation /assignment is carried out at both national and international levels, and all nations have statutory management structures specially designated for this. In Nigeria, for instance, there is the National Frequency Management Council (NFMC) responsible for the planning, coordination and bulk trans-sectorial allocation of radio spectrum to the regulatory bodies, namely the Nigerian Communications Commission (NCC), the Nigerian Broadcasting Commission (NBC) and the Ministry of Information and Communication (MIC), and acts as the focal coordinator of all frequency spectrum activities in Nigeria (William and Lau, 2011). Each of the above regulatory bodies is further mandated to equitably distribute its own allocated block of frequencies to the end users within its own sphere of authority and function. For instance, while the NCC assigns and monitors the use of spectrum by commercial users of telecommunications services, the NBC assigns broadcast frequencies it receives from NFMC to private & public radio and TV stations

This paper analyses the limitations and problems of terrestrial analogue television broadcasting to curb signal interference in Nigeria.

- *Author, Dr. Kamalu lectures masters degree program in Electrical and Electronic engineering in University of Port-Harcourt, PH, Rivers State, Nigeria. E-mail: ugokamax@yahoo.com*
- *Co-Author, Engr. Anyakora N.N is currently pursuing masters degree program in Electronic and Computer Engineering in University of Port-Harcourt, PH, Rivers State. E-mail: anyakorandidi@yahoo.com*

2 EXPERIMENTAL METHODOLOGY

2.1 To Confirm If the Television Stations Operate Within Their Allocated Frequency/Channel

This experiment was carried out in the transmitting room of the Television stations. The aim of this experiment was to examine the present UHF and VHF channel allocation plan of some selected Television in Nigeria. This experiment was carried out in six private owned and federal owned television stations covering the six geopolitical zones of the Nigeria. The equipment used for this experiment are: Spectrum analyzer (SA), Tracking generator and Computer (PC). First, the spectrum analyzer (SA) software was installed in the computer using a standard USB driver, which is used for communication between the PC and the Spectrum Analyzer. After then, the SA was connected to the PC with a standard USB 2.0 Mini cable. When it blinks a green LED followed by a steady red LED, the SA is now ready to be used. This same spectrum analyzer was then connected to the system under test and reference/vertical scale was adjusted to show from -20 dBm to +20dBm, which should cover (attenuated) max Transmitter power. To reduce influences from impedance mismatch, 50-Ω attenuators was connected next to the SMA connector of the Spectrum Analyzer. Depending on the target impedance, a 1-dB attenuator is sufficient. Based on radio spectrum, the center frequency was set but caution was taken so that the absolute maximum input level is +0 dBm is not exceeded. Exceeding this level can damage the SA. The connection status was then observed to display on left side of the status bar of the computer. The Start button was clicked to start measurement and frequency readings were taken.

2.2 Mathematical Models used for Interference Assessment

This section describes the mathematical models used for this study. The derivation of the models was based on an assumption of a simple scenario involving a directional mobile transmitter operating in the midst of other transmitters in the same operational area.

- Television Broadcast Stations

We refer to an ITU mathematical model (ITU, 2004), where a generic formula to calculate the keep-out region for a typical

ISSN 2229-5518
deployment of a Television station was proposed. In this model, it is assumed that the interference reaches the TV receiver over three different paths: through the antenna (path L1), through the coaxial TV cable (path L2), direct radiation into the TV-receiver (path L3).The combined interference power for the three paths was evaluated.

The desired received power (PD) at the TV antenna for channel N is expressed as:

$$P_D = \frac{E^2 c^2}{4 Z_0 f^2} G_{TV}(\theta_D) \quad (1)$$

where E is the field strength at the TV receiving antenna, c is the light speed; Z0 is the free space impedance, f is the operating frequency and GTV is the gain of the TV antenna. The incoming TV signal is assumed to be received in the main lobe of the TV antenna (θD = 0o). The total undesired received power (PU) will be the sum of the interference powers (could be operating in a different channel N+k,k = −3,−2, ..0, 20) at the receiver input from each interference path (L1, L2 and L3), as expressed by

$$P_U = \sum_{i=1}^{3} P_{U_i} = PG\left(\frac{G_1}{Lb_1} + \frac{G_2}{Lb_2} + \frac{G_3}{Lb_3}\right) \quad (2)$$

where P is the transmit power, G is the antenna gain in the direction of the TV antenna; G1 is the gain of the TV antenna which depends on the incidence angle of the received signal which is equivalent to GTV (θU) (path L1); G2 is the TV cable attenuation (path L2) and G3 is the TV receiver attenuation (path L3).

Finally, the Desired to Undesired (D/U) power ratio on channel N + K is calculated as the ratio between PD, the desired received power (Equation 2) and PU, the undesired received power (Equation 3) at the TV receiving antenna.

$$\frac{D}{U} = \frac{P_D}{PU}. \quad (3)$$

3 RESULTS AND DISCUSSION

3.1 Analysis of Interference in TV stations

The results obtained from the experiment 2 are shown in the table below.

TABLE 1 MEASURED FREQUENCY/CHANNEL OF THE TELEVISION STATIONS

FEDERAL GOVERNMENT OWNED- State Capital Stations								
Region	**Capital Stations**	**Frequency**	**Type of System**	**Vision mod. Type**	**Sound Mod**	**Channel**	**ErP (kW)**	**Period of Measurement**
NORTH CENTRAL	NTA ST. 1	471MHz	PAL G	AM	FM	21 VHF	50	MARCH 2, 2012
SOUTH SOUTH	NTA ST. 2	224.25MHz	PAL G	AM	FM	12 VHF	70	JANUARY 12, 2012
SOUTH WEST	NTA ST. 3	447.25MHz	PAL B	AM	FM	22 VHF	30	APRIL 4, 2012
SOUTH EAST	NTA ST. 4	210.25MHz	PAL B	AM	FM	10 VHF	40	NOVEMBER 14, 2012
NORTH EAST	NTA ST. 5	215.75MHz	PAL G	AM	FM	39 VHF	50	JUNE 21, 2012
NORTH WEST	NTA ST. 6	522.00MHz	PAL B	AM	FM	27 VHF	15	SEPTEMBER 14, 2012
PRIVATE OWNED								
Region	**Stations**	**Frequency**	**Type of System**	**Vision mod. Type**	**Sound Mod**	**Channel**	**ErP (kW)**	**Period of Measurement**
NORTH CENTRAL	TV St. 1	666.25MHz	PAL G	AM	FM	45 VHF	70	MARCH 2, 2012
SOUTH SOUTH	TV St. 2	614.60MHz	PAL G	AM	FM	39VHF	40	JANUARY 12, 2012
SOUTH WEST	TV St. 3	607MHz	PAL G	AM	FM	38 VHF	40	APRIL 4, 2012
SOUTH EAST	TV St. 4	479.25MHz	PAL G	AM	FM	22 VHF	50	NOVEMBER 14, 2012
NORTH EAST	TV St. 5	631.10MHz	PAL G	AM	FM	41 VHF, 43 UHF	10	JUNE 21, 2012
NORTH WEST	TV St. 6	535.20MHz	PAL G	AM	FM	21 VHF, 31 UHF	11	SEPTEMBER 14, 2012
STATE GOVERNMENT OWNED								
Region	**Stations**	**Frequency**	**Type of System**	**Vision mod. Type**	**Sound Mod**	**Channel**	**ErP (kW)**	**Period of Measurement**
NORTH CENTRAL	TV St. 7	140.4KHZ	PAL G	AM	FM	26 UHF	10	MARCH 2, 2012
SOUTH SOUTH	TV St. 8	775.25MHz	PAL G	AM	FM	60 UHF	14	JANUARY 12, 2012
SOUTH WEST	TV St. 9	503.25MHz	PAL G	AM	FM	53 UHF	12	APRIL 4, 2012
SOUTH EAST	TV St. 10	583.15MHz	PAL G	AM	FM	36 UHF	14	NOVEMBER 14, 2012
NORTH EAST	TV St. 11	503.25MHz	PAL G	AM	FM	22 UHF	10	JUNE 21, 2012
NORTH WEST	TV St. 12	609.55MHz	PAL G	AM	FM	29 UHF	10	SEPTEMBER 14, 2012

From the Table 1, the graph of Fig. 1 was developed. It was developed using a numerical computing environment MATLAB for a quick and efficient overview of the vast data.

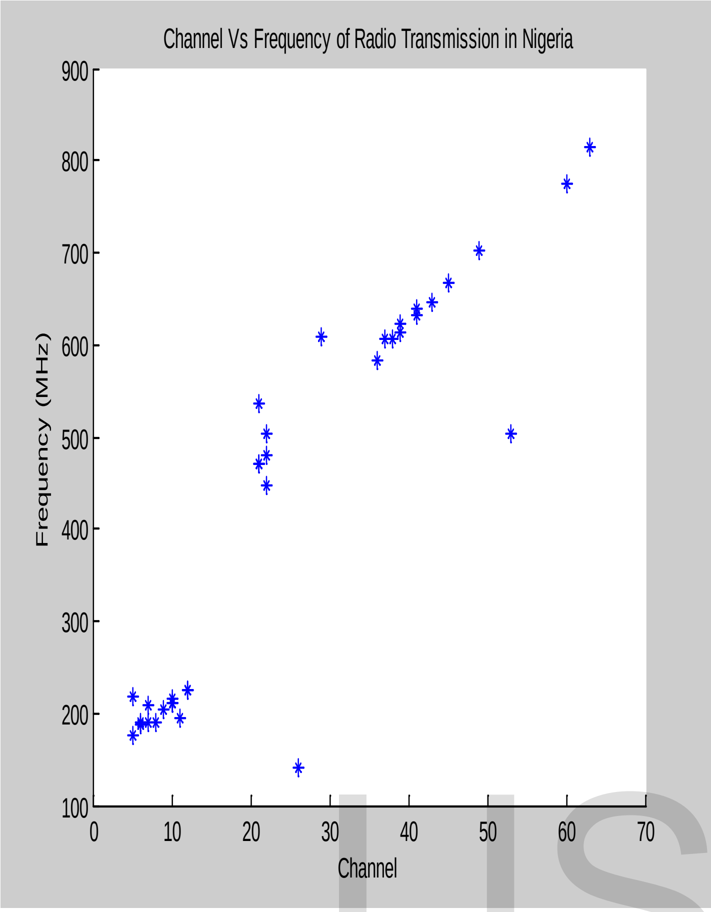

Fig 1: Channel Versus Frequency Of Some Selected Television Stations

From the above graph, it is observed that majority of the television stations lie in the VHF band, as such their frequencies lie between 170MHz and 225MHz. Also, most of this TV stations on VHF band are Federal Owned Stations (Shankar and Codeiro, 2011). This shows that the allocation of frequency/ channel to these stations is not properly planned or the frequencies have been assigned without following the appropriate national frequency allocation table. It is believed that this practice is the cause of interference. These television stations must be made to operate with distinct operating frequencies despite the use of the same channel of transmission. This ITU Radio Regulations and particularly its Table of Frequency Allocations is always revised and updated almost regularly in view of the enormous demand for spectrum utilization (Oloruni and Munday, 2008). Therefore, Nigeria should also update regularly and adjust properly their national frequency plan, no matter the high demand of more stations by operators.

3.2 Calculation of Interfering Signal Levels - Co-channel and Adjacent channel interference

As specified in the model, the threshold D/U ratio is determined to characterize the TV receiver's performance in presence of CCI or ACI. The Desired to Undesired (D/U) power ratio on channel N + K is calculated as the ratio between PD, the desired received power (Equation 1) and PU, the undesired received power (Equation 2) at the TV receiving antenna, where k can be -3, -2, -1, 0, 1, 2 etc .

With reference to this ITU mathematical model specified in equation of 2 and 3, D/U ratios was calculated using the measured values. This ITU model stipulates that the ratio should be kept below the received desired power level Erp in order to avoid interference to other stations 6.

Calculating for TV station 1, using the measured values to substitute in equations 2, 3 and 4:

Where: Antenna Gain = 16dBi, F=Operating Frequency, Z0 = free space impedance =376.73031 ohms, c = 299 792 458 m / s. Assuming the incoming TV signal is received in the TV antenna **ΘD =00. Since it is assumed that the signals reaches** the receiver only through the antenna path, L1, L2 and L3 =0; then Pu= PG

Calculating for the regions, the table below is developed.

ISSN 2229-5518

TABLE 2 D/U RATIO FOR THE TELEVISION STATIONS

State Capital Stations	Frequency	Channel	D/U Ratio	INTERFERENCE EFFECT
NTA STATION 1	471MHz	21 VHF	43.90	NO
NTA STATION 2	224.25MHz	12 VHF	56.80	NO
NTA STATION 3	447.25MHz	22 VHF	35.50	YES
NTA STATION 4	210.25MHz	10 VHF	44.70	YES
NTA STATION 5	215.75MHz	39 VHF	65.50	YES
NTA STATION 6	522.00MHz	27 VHF	20.00	YES
Stations	**Frequency**	**Channel**	**D/U Ratio**	**INTERFERENCE EFFECT**
TV Station 1	666.25MHz	45 VHF	70.70	NO
TV Station 2	614.60MHz	39VHF	55.90	YES
TV Station 3	607MHz	38 VHF	45.00	YES
TV Station 4	479.25MHz	22 VHF	45.00	NO
TV Station 5	631.10MHz	41 VHF, 43 UHF	9.80	NO
TV Station 6	535.20MHz	21 VHF, 31 UHF	10.90	NO
Stations	**Frequency**	**Channel**	**D/U Ratio**	**INTERFERENCE EFFECT**
TV Station 7	140.4KHZ	26 UHF	9.90	NO
TV Station 8	775.25MHz	60 UHF	14.00	NO
TV Station 9	503.25MHz	53 UHF	18.89	YES
TV Station 10	583.15MHz	36 UHF	14.60	NO
TV Station 11	503.25MHz	22 UHF	15.56	YES
TV Station 12	609.55MHz	29 UHF	11.00	NO

For a detailed explanation and illustration, TV station of Channel 27 (522MHz) is used as an example. The D/U ratio is developed while the effects of the TV channels besides it are investigated.

TABLE 3 D/U RATIO FOR THE TELEVISION STATION OF CHANNEL 27 (522MHZ)

Channel	D/U Ratio (low)	D/U Ratio (high)	Reference Data (ITU
N-6	-49	-52	-62
N-5	-50	-52	-70
N-4	-50	-52	-65
N-3	-42	-46	-55
N-2	-45	-48	-50
N-1	-38	-40	-45
N	20	20	20
N+1	-32	-35	-35
N+2	-42	-45	-48
N+3	-48	-48	-50
N+4	-50	-50	-50
N+5	-50	-49	-70
N+6	-50	-50	-62
N+7	-49	-52	-65
N+8	-50	-53	-72
N+9	-41	-42	-50
N+10	-50	-36	-72
N+11	-50	-41	-72
N+12	-50	-42	-72
N+13	-50	-51	-72
N+14	-50	-52	-72
N+15	-50	-52	-72
N+16	-50	-55	-72
N+17	-50	-55	-72
N+18	-50	-55	-72

From the table above, the figures are then plotted on the same graph.

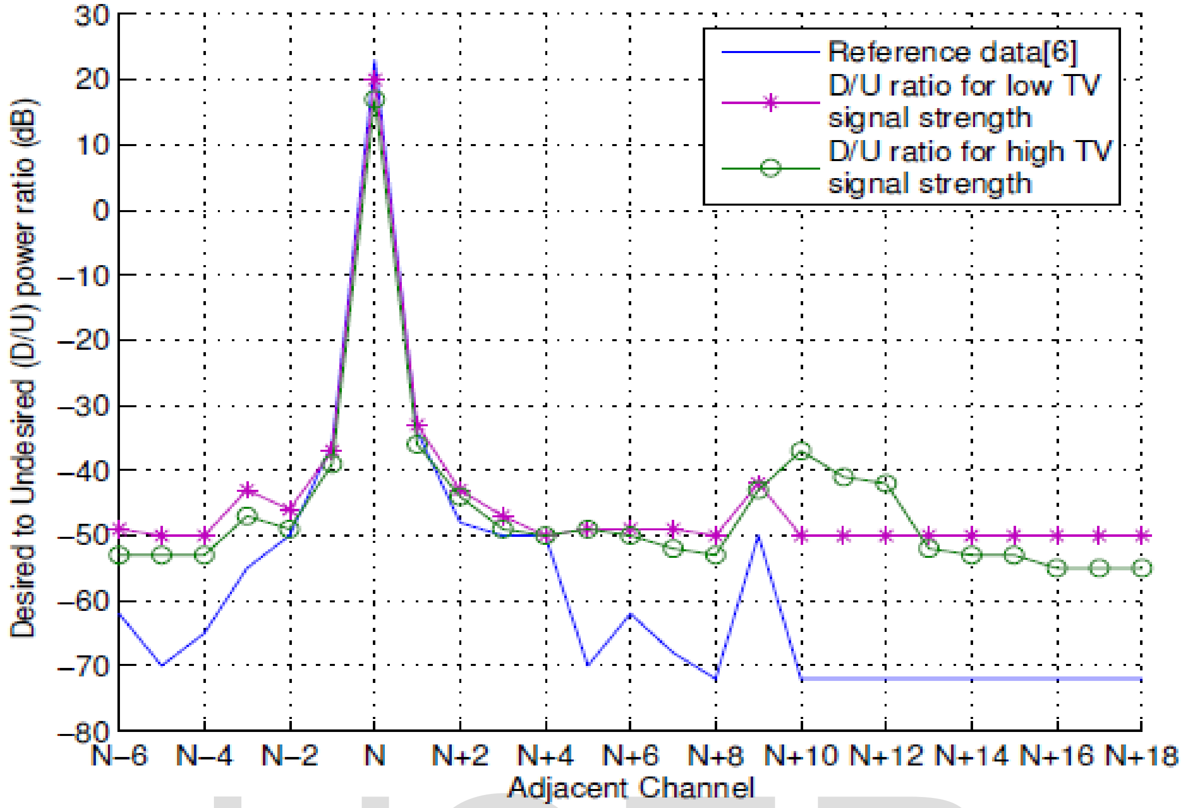

Fig 2: D/U ratios on TV Channel 27 (522 MHz)

From the graph, the highest point at which the adjacent channel interference can be found is traced down to Channel N-1 and N+1 which is the closest to the wanted signal. This is the major point of interference. Still interpreting from the graph, interference received in each adjacent channel does not fulfill the required threshold of desired to- undesired power (D/U) ratio to avoid interference to the TV reception. An observation that had also been confirmed in this study is the anomaly that lies in adjacent channel N+9. In addition, intermodulation effects are observed in channels N+11; N+12 and N+13 for this TV signal level. Also, it can be seen that the transmissions on N+1;N+2and N+9 will be most likely to affect the TV reception as shown in both simulation and measurement.

4 CONCLUSIONS

From the analysis above, it could be deducted that to ensure interference-free broadcasting, adherence to such assigned/allocated parameters as channel separation (bandwidth and spacing), minimum field strength, antenna heights and transmit frequency is an important factor, particularly, in those regions that have highest number of Television broadcast stations and tend to compete for more network capacity and coverage areas. More specifically, our findings show a cluster of frequencies which leads to the high level of interference experienced in Television in the country today. The threat of interference was also investigated as a function of these source agents: transmitting power, transmitter frequency, receiver frequency, and most importantly, the proximity of the transmitter to the potential receiver and to the next adjacent transmitter of another Television station. It was found that the effect of this interference degrades the reception of desired signals. When the received power levels of an interfering signal are high relative to the desired signal such systems experience degradation of service or possibly an interrupted. Also, from the measurements in this study, it was observed that there is an aggregate effect for the interference received in different adjacent channels accessed by multiple simultaneous TV channels. Thus the weighted sum of the total received interference power in the adjacent channels or the equivalent co-channel interference should be kept below a certain threshold as specified by ITU. This means that individual received interference power generated by each TV channel in a particular channel should stays below its threshold D/U ratio as not to cause interference to the TV reception.

This study also evaluated a prediction model specified by ITU which helps to prove whether the permitted limit values have been adhered to, or which service provider has exceeded the limits, and by how much. This result to a need to reduce output power in order not to exceed the thresholds provided. In addition, this study observed that the frequency allocation systems are not clearly designated or are not adhered to by the operators.

ISSN 2229-5518

REFERENCES

[1] Atanda, J. A (2001): The Analysis of Signal Interference in Radio and Television Stations using LEE method, Ibadan: Ibadan University Press, pp 3-34

[2] Akinleye, L. and Ojebode, A (2009): Interference Modelling and Management for Radio and Television in Nigeria" Topical issues in communication arts and sciences Volume II, pp 15-24

[3] B. Oloruni and S. Munday, "Adjacent and Co Channel Interference Disturbances From A Terrestrial Television Signal On Analogue Pal Systems 2008

[4] ITU 2004. "Spectrum Management for a Converging World: Case Study of Africa. "International Telecommunication Union. Workshop on Spectrum Management for a Converging World. Geneva. http://www.itu.int/osg/spu/ni/spectrum/aust-rsm.doc.

[5] S. Shankar and C. Cordeiro; "Analysis of Aggregated Interference at DTV Receivers in TV bands". Proceedings of the Third International Conference on Cognitive Radio Oriented Wireless Networks and Communications, May 2011.

[6] ITU 2009, 'Radio and Television Broadcasting, Recommendations and Reports of the CCIR,XVI Plenary Assembly, Volume VI, Geneva, International Telecommunications Union

William W. F and Lau A, 2011. "Service planning for terrestrial audio broadcasting".