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Determination of Coverage Area of Nigeria Television Authority (NTA), Television Signal in Kebbi State, Nigeria

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Abstract*— The worldwide development of thousands of terrestrial broadcasting networks over the past 90 years depended crucially upon the prediction and measurement of radio field strength. This work determines the actual coverage area of NTA television signal in Kebbi State, Nigeria, by quantitatively measuring the signal level of the signal. The signal level of the transmitter of Nigeria Television Authority (NTA), Birnin-Kebbi channel 39 (615.25 MHz), and the corresponding distances were measured along some radial routes with the transmitting stations as the reference point. This measurement was taken using Digital Signal Level Meter and Global Positioning System (GPS). From the data obtained, Surfer 13 software application was used to draw contour map of the signal level around the transmitting station to determine the coverage areas of the station. The result obtained show that the present configuration of the transmitter of the television station does not give an optimal coverage of the state. Only 4.05% of the entire land mass of the state has television signal coverage. Consequently, greater percentage of Kebbi State is completely out of NTA television signal coverage. So, there is need to have repeater stations at some intervals to ensure reception of the television signal throughout the state.

Keywords—Signal coverage, NTA, UHF, transmitter

I. INTRODUCTION

Signal attenuation is the reduction in power density of an electromagnetic wave as it propagates through a medium, usually by free space [1]. Signal attenuation is a major component in the analysis and design of the link budget of a telecommunication system. This term is commonly used in wireless communications and signal propagation. Signal attenuation occurs due to many effects in signal propagation which include path loss, shadowing and multipath fading. Path loss can also be influenced by terrain contours, environment (urban or rural, vegetation and foliage), propagation medium (dry or moist air) [2]. The distance between the transmitter and the receiver, the height and location of the antennas [3]. Signal attenuation includes propagation losses caused by the natural expansion of the radio wave front in free space (which usually takes the shape of an ever-increasing sphere), absorption losses (sometimes called penetration losses), when the signal passes through media not transparent to electromagnetic waves, diffraction losses happens when part of the radio wave front is obstructed by an opaque obstacle, and losses caused by other phenomena [4]. Path loss is caused by dissipation of the power radiated by the transmitter as well as effects of the propagation channel. The signal radiated by a transmitter may also travel along many different paths to a receiver simultaneously; this effect is called multipath. Multipath waves combine at the receiver antenna, resulting in a received signal that may vary widely, depending on the distribution of the intensity and relative propagation time of the waves and bandwidth of the transmitted signal. The total power of interfering waves in a Rayleigh fading scenario varies quickly as a function of space (which is known as a small scale fading). Small-scale fading refers to the rapid changes in radio signal amplitude in a short period of time or travel distance. Path loss exponent is one of the most important parameter in signal attenuation models and once it is known for an environment, coverage planning and propagation analysis can be done easily.

At broadcast frequencies in the ultra high frequency (UHF) bands (300 MHz - 3 GHz), propagation is usually by ground waves which consist of direct wave, ground reflected and surface wave. Therefore, in these frequency bands, the electrical parameters of the ground, curvature of the earth surface, height of the antenna and weather conditions influence wave propagation. The electric field strength at a given distance from the transmitter is attenuated by these parameters, with the result that radio services in the UHF bands are limited to distances close to the transmitter. The coverage areas of broadcast stations are usually classified into primary, secondary and fringe areas. Apart from weather conditions; the size of each of these areas also depends on the transmitter power, the directivity of the aerial, the ground conductivity and the frequency of propagation. The coverage area decreases with increase in frequency and reduction in the ground conductivity [5]. The primary coverage area is defined as a region about a transmitting station in which the signal strength is adequate to override ordinary interference in the locality at all times, and corresponds to the area in which the signal strength is at least 60 dBμV. The quality of service enjoyed in this area can be regarded as Grade A1. The appropriate value of the signal strength for this quality of service is also dependent on the atmospheric conditions and man-made noise in the locality. The signal strength also depends on whether the locality is rural, industrial or urban. The secondary coverage area is a region where the signal strength is often sufficient to be useful but is insufficient to overcome interference completely at all times. The service provided in this area may be adequate in rural areas where the noise level is low. The secondary coverage area corresponds to the area in which the signal strength is at least 30 dBμV, but less than 60 dBμV. The quality of service enjoyed in this area can be regarded as Grade B1. The fringe service area is that in which the signal strength can be useful for some periods, but its service can neither be guaranteed nor protected against interference. This is an area in which the signal strength is greater than 0 dBμV, but less than 30 dBμV. Such an area may be said to enjoy Grade B2 service [6]. This work determines the actual coverage area of NTA television signal in Kebbi State, Nigeria, by quantitatively measuring the signal level of the signal

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II. STUDY AREA

Kebbi State is a State in north-western Nigeria with its capital at Birnin-Kebbi. It is located at Latitude, 11° 30 N and Longitude 4° 00 E with an area of 36,800 square kilometers and population of about 3,238,628.
Kebbi State shares boundaries with Sokoto State on the North-Eastern axis, Zamfara State on the Eastern part, Niger state on the Southern part and Republic of Niger on the Western part.

Kebbi State enjoys a Tropical Continental type of climate. This is largely controlled by two air masses, namely Tropical Maritime and Tropical Continental, blowing from the Atlantic and the Sahara Desert respectively. These air masses determine the two dominant seasons wet and dry. The wet season lasts from April to October in the south and May to September in the north; while the dry season lasts for the remaining period of the year. Mean annual rainfall is about 800 mm in the north and 1000 mm in the south. Temperature is generally high with mean annual temperature of about 26 ^{0}C in all locations. However, during the harmattan season (December to February) the temperature can go down to about 21 °C and up to 40 °C during the months of April to June. [8] Nigeria: Physical setting – Kebbi State, taken from https://onlinenigeria.com/kebbi-state/?blurb=300

The natural vegetation of the State consists of a Northern Guinea Savannah in the south and southeast while in the north, the Sudan Savannah consists of open woodland with scattered trees such as acacia aibida (gawo), Parkia Clappertoniana, Porassus and dum palms. Kebbi State is divided into three relief regions, which are the high plains in the south and south east, the plain landscape in the north and the riverine lowland of the Niger and lower Rima valleys. The high plains are characterized by dissected crystalline rocks with hill ranges and domical rises (inselbergs).

It is approximately 700 m above sea level. The plain landscape forms part of the vast Sokoto plains which is an end tertiary plantation surface. Is a repetitious lowland, sedimentary in origin, with average height of about 300 m above sea level. The plain surface is interrupted by isolated flat-topped lateritecapped hills and ridges. The riverine lowlands are mainly the flood plains of the major rivers which are very wide, up to 8 Km in many areas. They are characterized by levees, backswamos and terraces on the natural vegetation. And the fig 1 blow shows where Kebbi State is located on the map of Nigeria.

Fig1. [9] Map of Kebbi State taken from https://en.wikipedia.org/wiki/Kebbi_State

Table 1. Parameters of the N.T.A. Channel 39 Birnin-Kebbi Broadcasting Station

Frequency of Operation	Ultra High Frequency
Frequency Bandwidth	619.25 MHz
Transmitting Power	8 kW
Effective Isotropically Radiated Power	3.1 kW
Antenna Directivity	Omni-directional
Antenna Polarization	vertical
Maximum height of the transmitting antenna	110 m

III. DATA COLLECTION AND ANALYSIS

This research was carried out for Nigeria Television Authority (NTA) Birnin-Kebbi, channel 39. NTA Birnin-Kebbi transmits at a frequency of 619.25 MHz and the station mast was 110 m high. The output power of the transmitter during the period of this work was substantially constant at 3.1 kW. Measurement of the video signal levels was done along three radial routes, designated Route A, B, and C from the transmitting station, which was the reference point as shows in fig 2. The signal was received by means of a dipole antenna, 1.5 m high connected to a Digital Signal Level Meter, GE-5499 (DSL Meter) and a Global Positioning System, GPS GarmineTrex 10 was used to determine the location (longitude and latitude) of each measuring point and the corresponding distances from the base of the transmitting station.

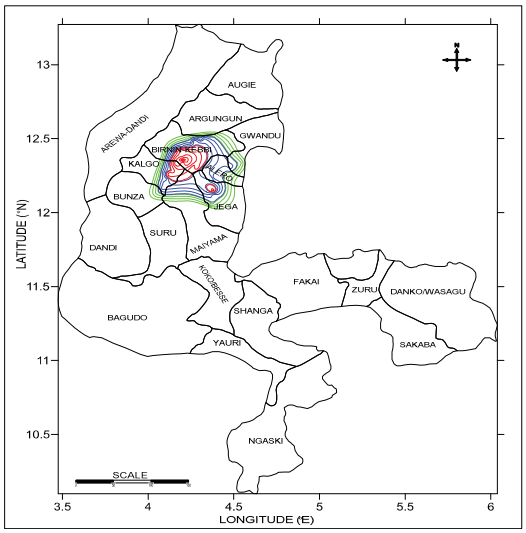
Surfer 13 software application was used to draw contour maps of the signal levels around the transmitting stations with the data obtained to determine the coverage areas of the stations. The coverage area is divided into three different areas based on the following classification of signal strength E [7].

i. Primary Coverage Area, E > 60 dBμV
ii. Secondary Coverage Area, 60 dBμV > E > 30 dBμV
iii. Fringe Coverage Area, 30 dBμV > E > 0 dBμV

Fig 2:[10] Map with routes in Kebbi State https://www.google.com/maps/place/Kebbi

IV. RESULTS AND DISCUSSION

Fig 3 shows the contour map of the signal levels around the transmitting station and its coverage areas in the state, while Tables 2 and 3 shows the television signal coverage areas as percentage of the total land mass and the local government areas respectively. The results obtained show that the present configuration of the transmitter of the television station do not give an optimal coverage of the state. Only 4.05% of the entire land mass of the state has television signal coverage. So, greater percentage of Kebbi State is completely out of NTA television signal coverage and the contour maps show the need for repeater stations at appropriate intervals to provide increased signal coverage and reception of NTA television signal in local governments with weak or no signal within the entire state.



E > 60 dBμV (Primary Coverage Area)
60 dBμV > E > 30 dBμV (Secondary Coverage Area)
30 dBμV > E > 0 dBμV (Fringe Coverage Area)

Fig 3. Coverage area of the NTA Birnin-kebbi in Kebbi State

Table 2. Percentage of the coverage areas of the television station relative to the total land mass of Kebbi State

Station	% of Primary coverage area	% of Secondary coverage area	% of Fringe coverage area	Total % of coverage area
NTA Birnin-Kebbi	0.67%	1.52%	1.86%	4.05%

Table 3. Percentage of the local government areas covered by the NTA Birnin-Kebbi station in Kebbi State

L.G.A	Average Distance (km) (from the transmitting station	% of L.G.A with Primary coverage area	% of L.G.A with Secondary coverage area	% of L.G.A with Fringe coverage area	Total % of L.G.A coverage area
Birnin-Kebbi	3.52	12.97%	18.82%	16.52%	48.31%
Kalgo	1.59	15.50%	11.24%	12.40%	39.14%
Jega	18.71	3.47%	13.88%	19.55%	36.90%
Maiyama	25.29	1.60%	12.44%	11.24%	25.28%
Aleiro	24.38	-	32.75%	49.99%	49.99%
Bunza	8.96	-	0.68%	15.80%	16.48%
Gwandu	32.58	-	3.19%	10.54%	13.73%
Argungun	21.99	-	-	1.94%	1.94%

V. CONCLUSION

In conclusion, only 4.05% of the entire land mass of Kebbi State has NTA television signal coverage. More than 95% of the state does not receive NTA television signal from the television station. Thus, the present configuration of the transmitter does not give optimal coverage of the total land mass of Kebbi State. So, installation of repeater stations at certain intervals of distance to provide reception of NTA television signal for the entire state is necessary.

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