SPSBIC 2017

4 - 5 May, Minna Nigeria

SCHOOL OF PHYSCIAL SCIENCES
1ST BIENNIAL INTERNATIONAL CONFERENCE

PROCEEDINGS

Theme:
Science Technology and Innovation (STI):
The Vision for Poverty Reduction and Sustainable Development

FEDERAL UNIVERSITY OF TECHNOLOGY
MINNA, NIGER STATE, NIGERIA

DETERMINATION OF COVERAGE AREA OF VHF TELEVISION SIGNAL IN BENUE STATE, NIGERIA

Moses Abiodun Stephen*[1], Oyedum Onyedi David[2], Ajewole Moses Oludare[3]
[1,2]Department of Physics, Federal University of Technology Minna, P.M.B. 65 Minna, Niger State, Nigeria
[3]Department of Physics, The Federal University of Technology Akure, P.M.B. 704 Akure, Ondo State, Nigeria
[1]abiodun.moses@futminna.edu.ng*
[2]oyedumod@yahoo.com
[3]oludare.ajewole@futa.edu.ng

* Corresponding author

Abstract

This study investigates the coverage areas of VHF television signal in Benue State, Nigeria, by quantitatively measuring the electric field strength of the signals. The signal levels of the transmitter of Nigeria Television Authority (NTA), Makurdi, Channel 10, on a frequency of 210.25 MHz were measured along several radial routes with the transmitting stations at focus. The distances, elevations above the sea level and locations (longitude and latitude) where every signal level was taken were also measured. The signal levels were taken using Digital Signal Level Meter GE-5499 while other measurements were done with GPS 72 – Personal Navigator. Measurements were taken along all the accessible radial routes in the state until all the signals faded away completely. From the data obtained, Surfer 12 software application was used to draw the contour maps of the signal levels of the areas covered by the transmitting station. The results obtained showed that the present configuration of the transmitter of the television station does not give an optimum coverage of the state. Only 6.13% of the entire land mass of the state has the television signal coverage, consequently, greater percentage of Benue State is out of the television signal coverage. So, there is need to have repeaters stations at some intervals to ensure reception of the television signals throughout the state.

Keywords: coverage areas, electric field strength, transmitter, VHF

1. Introduction

At broadcast frequencies in the VHF band (30 – 300 MHz), propagation is usually by direct wave. Therefore, in these frequency bands, height of the antenna, curvature of the earth surface and weather conditions influence wave propagation. The degree to which these factors affect propagation depends primarily on the frequency of the wave and the polarization (Hall, 1991). The electric field strength at a given distance from the transmitter is attenuated by these parameters, with the result that radio services in the VHF band are limited to distances close to the transmitter. The present trend in broadcasting is to use widespread broadcast transmitter of medium or VHF or UHF range of frequencies to serve areas not far away from the transmitter.

Coverage areas of broadcast stations are usually classified into primary, secondary and fringe areas. The size of each of these areas 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 (Ajayi and Owolabi, 1975).

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. The primary coverage area corresponds to the area in which the electric field 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 electric field strength for this quality of service is dependent on the physical features of the environment and manmade noise in the locality. The relevant electric field strength also depends on whether the locality is rural, industrial or urban. The secondary coverage area is a region where the electric field 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 electric field 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 can be regarded as that in which the electric field strength can be useful for some periods, but its service can neither be guaranteed nor be protected against interference. This is an area in which the electric field strength is greater than 0 dBμV but less than 30 dBμV. Such an area may be said to enjoy Grade B2 service (Ajayi and Owolabi, 1979).

This study investigated the coverage areas of the Nigeria Television Authority, Makurdi Zonal Network Centre (NTA Makurdi, Channel 10), with broadcasting frequency of 210.25 MHz, by means of quantitative measurement of the electric field strength signals.

1.0

2. Theoretical Background

The attenuation experienced by a radio wave is the result of absorption and scattering. At wavelengths greater than a few centimeters, absorption by atmospheric gases is generally thought to be negligibly small except where very long distances are concerned. However, cloud and rain attenuation have to be considered at wavelengths less than 10 cm, and are particularly pronounced in the vicinity of 1 and 3 cm.

It is helpful to recall that when an incident electromagnetic wave passes over an object whose dielectric properties differ from those of the surrounding medium, some of the energy from the wave is;

(a) absorbed by the object and heats the absorbing material (this is called true absorption), and
(b) some of the energy is scattered, the scattering is generally smaller and more isotropic in direction (Bean and Dutton, 1968).

2.1 Radio Propagation at VHF Band

Radio reception of broadcast services at VHF is almost entirely dependent on the space wave because, except for reflections due to the rare Sporadic E (Es) and trans-equatorial (TE) ionospheric effects, transmissions at $f > 30$ MHz ordinarily pass through the ionosphere without being reflected back to the earth. The height of transmitting antenna (usually $> \lambda$) and high attenuation of the surface wave normally render it negligible, except for diffraction over and around obstacles which may occur when the space wave encounters obstructions such as buildings, hills, etc. (Oyedum, 1999).

Diffraction allows short-range reception into built-up areas, though mobile systems are subject to screening by hills and to multipath effects caused by scatter or reflections off obstacles. In general the precise prediction of signal level is not possible, and it is necessary to specify the deviation from the calculable median expressed for a given percentage of locations and percentage of time (Hall, 1991).

In clear air the radio refractive index of the troposphere is slightly greater than unity (typically about 1.0003). The way in which refractive index changes with height has much consequence for radio-wave propagation at frequencies greater than about 30 MHz. Above 30 MHz the wavelength is comparable with the distance over which variations of refractive index occur in the troposphere. The tropospheric refractive index variations are due to changes of temperature, pressure and humidity. The refractive index of the troposphere generally decreases with height. This leads to a slight downwards refraction of radio rays, which can be very important for communication at VHF, UHF and SHF. If the rate of refractive index decreases with height is sufficiently large and extends over a sufficient height interval and horizontal extent, it may give rise to atmospheric ducts which guide radio energy far beyond the normal horizon. Normal duct heights are such that complete trapping within them occurs only at centimeter wavelengths, but partial trapping (and very rarely total trapping) may also be found at the shorter metric wavelengths.

If over a large horizontal area, the refractive index decreases with height abruptly, this may lead to partial reflection of radio energy. Both ducting and partial-reflection mechanism may cause multipath interference on line-of-sight or inter-path interference on beyond-horizon links. Randomly distributed small-scale spatial fluctuations of refractive index about the local mean value cause weak signal levels always to be present at large distance beyond the horizon. This is due to tropospheric scattering from the irregularities, and such scattering may be used to provide radio communication over hundred kilometers of line-of-sight paths. These refractive index fluctuations may cause significant scintillation (rapid fading) which is large in magnitude for longer range or higher frequency. For two terrestrial radio terminals within line of sight, there may often be a ground reflected ray in addition to the direct ray. There may also be a reflected ray (or more than one) from layers of abrupt change of refractive index with height. According to their relative phase, the "multipath" contributions may give rise to slow signal enhancement or fading.

The effect of obstacles such as hills, building or trees on a radio wave depends on its wavelength. Such obstacles cause reflection (and multipath), diffraction and absorption. In a built-up area this results in an incalculable field with wide variations. The losses caused by absorption and scattering increase with frequency, until, at frequencies above UHF, walls or masonry more than about 20 cm thick may be regarded as opaque, together with buildings (except those of very light construction) and good land which is visually opaque (Hall, 1991).

2.2 Area Coverage

A traditional broadcast system comprises several receivers which receive signals from a single, fixed base station. In most cases the base station is centrally located within the area to be served and is connected to the control room via a radio link. A straightforward approach to the problem of providing coverage over very large areas would therefore be to erect a very high tower somewhere near the centre of the required coverage area and install a powerful transmitter. This technique is used by the broadcasting authorities; their transmitting masts may be over 300 m high and they radiate signals of many kilowatts. Broadcasting always aims to deliver a strong signal to many receivers all tuned to the same broadcast.

If a single high mast were situated in the middle of a territory with sufficient transmitter power to cover large area, then that frequency would not be reusable anywhere close to the coverage area. For traditional broadcast services, if the area is too large to be economically covered by one base station or if geographical conditions produce difficulties, an alternative is to have a large number of low-power transmitters radiating from short masts, each covering a small territory but permitting reuse of the frequencies assigned to them many times in a defined geographical area. This is the basis of the 'cellular radio' approach to area coverage and is extremely effective (Appleby and Garrett, 1985; Department of Trade and Industry, 1985). In this case the transmitters are all operated at nominally the same frequency so that whatever the location of the receiver within the overall coverage area, it is within range of at least one of the base stations and its receiver does not have to be retuned. This method of operation is well established and is known as quasi-synchronous or simulcasts operation. It exploits the fact that although a transmission frequency cannot be used for another service close to the desired coverage area because of interference, it can be reused for the same service (Dernikas, 1999).

3. Study Area

Benue State is a state in north central Nigeria and the capital is Makurdi. Benue State lies within the lower river Benue trough in the middle belt region of Nigeria. Benue State lies between latitude 6.42°N and 8.13°N and longitude 7.78°E and 10°E (Figure 1) and shares boundaries with Nassarawa, Taraba, Cross-River, Enugu and Kogi. It also shares a boundary with the Republic of Cameroun. The total land mass of Benue State is about 33,955 square kilometers and has a population of 4,780,389 (2006 census).

Benue State experiences two distinct seasons, the rainy season and the dry season. The annual rainfall ranges from 100 mm to 200 mm. The rainy season starts in April to October, while the dry season starts in November to March. The temperature varies between 23°C to 37 °C in the year. However, the south eastern part of the state close the Obudu-Cameroun Mountain varies, it has a cooler climate similar to that of the Jos Plateau. The western and southern part of the state has rain forest vegetation which consists of tall grasses and tall trees while the eastern and northern parts has Guinea savannah vegetation which are mixed trees and grasses that are of average height. (http://benuestate.gov.ng/wp/historical-background/, 2013)

Figure 1: Location of Benue State in Nigeria

4. Methodology

NTA Makurdi, Channel 10 has 5 kW transmitter, Rohde and Schwarz (Germany product). The video carrier frequency of the station was 210.25 MHz and the audio carrier frequency was 215.75 MHz. The output power of the transmitter was constant at 1.1 kW all through the period of this work. The mast on which the transmitting antenna was mounted was 150 m. The signal levels of the television station was taken along four radial routes from the transmitting station as shown in Figure 2, using Digital Signal Level Meter GE-5499. The signal level corresponding distances, elevations above the sea level and locations were also measured using GPS 72 – Personal Navigator. Measurements were taken (at distances further from each transmitter) along these radials until all the signals faded away completely.

From the data obtained, Surfer 12 software application was used to draw the contour maps around the transmitting stations for signal levels to determine the coverage areas around the state. The coverage areas are divided into three different areas based on the following classification of electric field strength E:

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

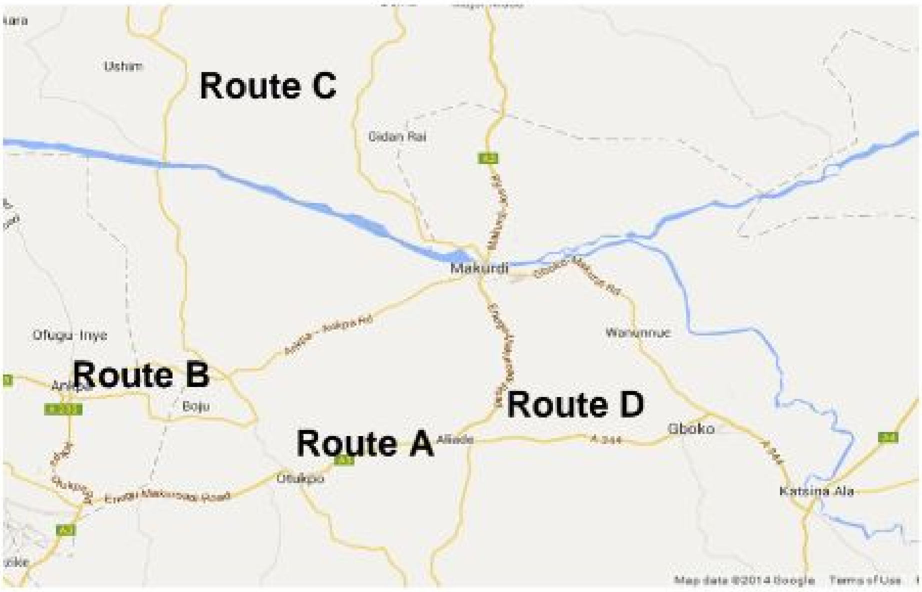

Figure 2: The routes along which measurements were taken in Makurdi (http://www.viewphotos.org/nigeria/flat-map-of-Makurdi-145.html, 2013)

5. Results and Discussion

Figure 3 shows the contour map for signal levels around the transmitting station and the coverage area in Benue State. Tables 1 and 2 show the television signal coverage area as percentages of the total land mass of the state and that of the Local Government Areas.

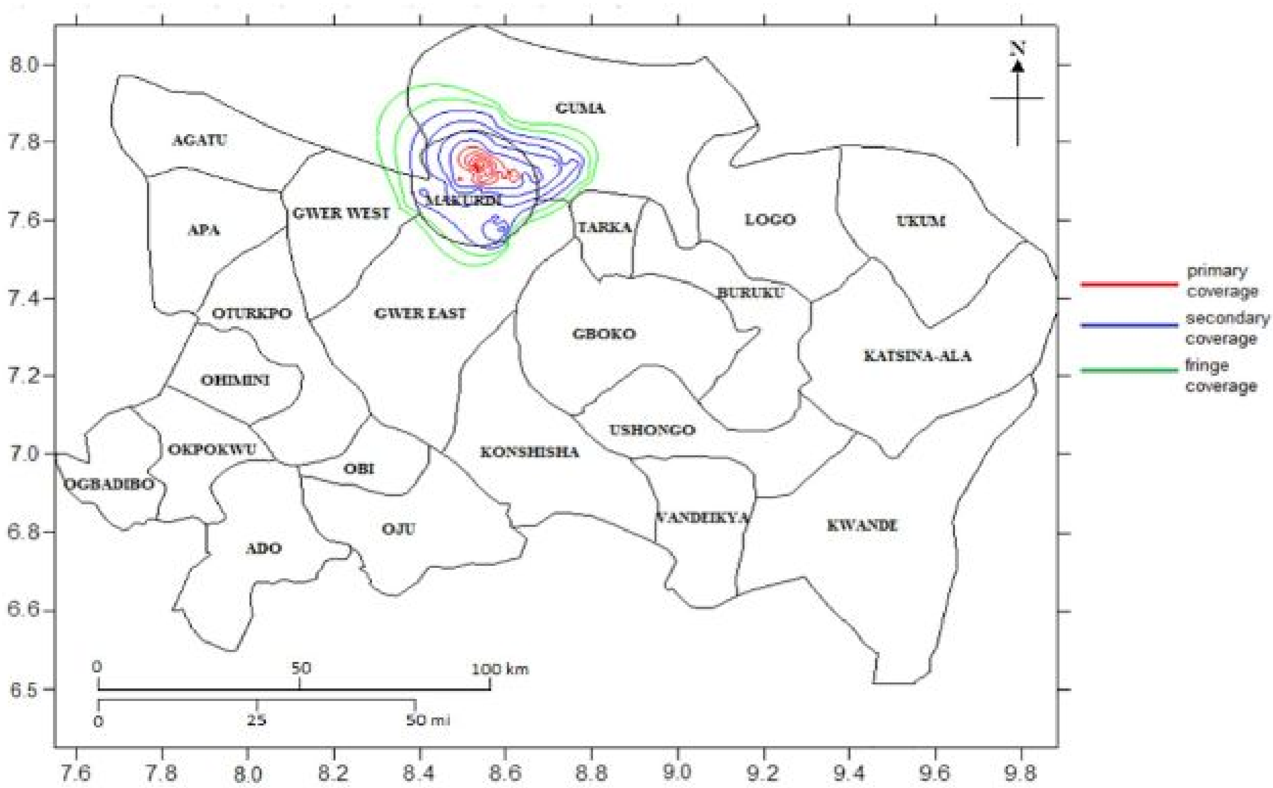

Figure 3: Coverage Area of the NTA Zonal Network Makurdi, Channel 10 in Benue State

Table 1: Percentage of the Coverage Areas of NTA Makurdi relative to the total land mass of Benue State

Station	Primary coverage (%)	Secondary coverage (%)	Fringe coverage (%)	Total coverage (%)
NTA Makurdi, Channel 10	0.39	3.07	2.67	6.13

Table 2: Percentage of the Local Government Areas Covered by NTA Makurdi in Benue State

L.G.A	Primary coverage (%)	Secondary coverage (%)	Fringe coverage (%)	Total coverage (%)
Makurdi	11.43	80.00	8.57	100
Guma	-	11.29	13.71	25.00
Gwer-West	-	-	6.25	6.25
Gwer-East	-	-	4.55	4.55
Outside the State	-	-	7.14	7.14

The field strength measurements of the transmitting station shows that 0.39% of the entire land mass of Benue State has the television signal strong enough to override ordinary interference in the locality at all times, which comprise the primary coverage area. About 3.07% of the state also enjoys good television signal of the station, but not strong enough to overcome interference completely at all times, thus within the secondary coverage area. The service provided in this area may be adequate in rural areas where the noise level is low. Also, 2.67% of the state is in fringe service areas of the television coverage. In such areas, the service can neither be guaranteed nor protected against interference, and antennas with high antenna gain and heights higher than the surrounding buildings and obstacles are needed to receive good signals.

6. Conclusion

In conclusion, only 6.13% of the entire land mass of Benue State has the television signals coverage. More than 93% of the state does not receive television signals from the television station. Thus, the present configuration of the transmitter does not give optimal coverage of the total land mass of Benue State. So, installation of repeater stations at certain intervals of distance to provide reception of television signals for the entire state is necessary.

Although 7.14% of the coverage area enters into Nasarawa State, the television station may not constitute potential interference to any of the television stations in Nasarawa States because of the shape of the boundary between the two states. Hence, the station operates in compliance with the Nigeria Broadcasting Commission (NBC) regulations.

References

Hall, M.P.M. (1991), Overview of Radio wave propagation, Peter Peregrines Ltd., London, United Kingdom pp 9-16)

Ajayi, G .O. and Owolabi, I. E. (1975), Medium Wave Propagation Curves (for use in medium wave transmission planning and designed), Technical Report of the Radio wave propagation Research Group Department of Electronic and Electrical Engineering, University of Ife, Nigeria.

Ajayi, G. O. and Owolabi, I. E. (1979), Coverage Area of the 10KW, 702 KHz Medium Wave Transmitter at Minna and Feasibility Studies for full Radio Coverage of Niger State, Technical Report of the Electrical Communication Consultancy Unit (ECCU), Department of Electrical and Electronics Engineering, University of Ife, Nigeria.

Bean, B. R. and Dutton, E. J., (1968), Radio Meteorology, Dover Publications, Inc. New York, 261-270.

Oyedum, O. D. (1999), VHF/UHF. Broadcast Service and Interference, *Journal of Science, Technology and Mathematics Education (JOSTMED),* Vol. 2 No. 2, 87-94.

Appleby, M.S. and Garrett, J. (1985), Cell net cellular radio network. *Br. Telecommun. Engng*. 4, 62-9

Department of Trade and Industry (1985), A Guide to the Total Access Communication System. DTI, London

Dernikas, D. (1999), Performance evaluation of the TETRA radio interface employing diversity reception in adverse conditions. PhD thesis, University of Bradford.

Flat map Makurdi - Benue-State, Retrieved from http://www.viewphotos.org/nigeria/flat-map-of-Makurdi-145.html, 2013

Government of Benue State – Historical Background, Retrieved from http://benuestate.gov.ng/wp/historical-background/, 2013