EFFECT OF MOUNTAINOUS TERRAIN ON RADIO WAVE RECEPTION IN THE UHF FREQUENCY BAND, IDANRE AS A CASE STUDY.

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THE FEDERAL UNIVERSITY OF TEHNOLOGY

AKURE

AUGUST, 2003

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THE FEDERAL UNIVERSITY OF TECHNOLOGY

AKURE.

AUGUST, 2003

CERTIFICATION

This is to certify that this Project was carried out by Mr. Akingbade Kayode Francis in the Department of Electrical and Electronic Engineering, School of Engineering and Engineering Technology, in partial fulfillment of the requirement for the award of Master degree in Electrical and Electronics Engineering of The Federal University of Technology, Akure. It has not been submitted elsewhere for the award of a degree.

Biai Adeloye
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Engr. ~~(Dr) V.S.A.~~ Adeloye
Supervisor & H.O.D EEE

31-8-2003.
....
Date

DEDICATION.

This project is dedicated to the secret of my breakthrough, God Almighty and to my lovely daughter, Sharon.

ACKNOWLEDGMENT

"Unless the Lord build the house, those who build it labour in vain".

Hence, the extent to which any man succeeds depends on the will of Almighty God as well as those elements within his social and material environment. I am therefore grateful to the faithful Almighty God who has always been my source of strength, knowledge and understanding throughout the course of my study.

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ABSTRACT.

The research is focused on the effect of mountainous terrain on radio wave reception at UHF band. Since the wave in the high frequency range travels straight from the transmitter to the receiver, it is limited by the line of sight: This implies that reception at this frequency range may be disturbed by factors such as Hills, Mountains, Trees, foliage, and high-rise buildings.

Hence, television signal reception in hilly areas suffers from ghosting and noise. Despite the high antenna used, television subscribers in the valley areas, behind the high mountain, (shadow region) receive very poor signal. Idanre is chosen as the case study due to its topographical situation, which could be referred to as the worst case in Ondo State. The line of sight distance from the chosen broadcasting station to the selected areas and the height of the obstructing hills were determined. Spot height above sea leve measurements were taken. Measurements of signal field strength and quality of the picture signal were carried out round the town and its environs using the appropriate field strength meter.

Then, Fourier analysis method is used to analyse the results obtained to show the impact of multipath and reflection off the hills on the quality of the picture signal received on the signal field strength meter. The result obtained here could then be applicable to other areas of similar topography like Akoko and Okegbo/Ileoluji areas of Ondo State., though there might be slight variations in the results obtained due to distance from the transmitter and the topography of area.

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CHAPTER ONE

1.0 INTRODUCTION

Waves at UHF frequencies are shorter than those at VHF frequencies with the result that the range decreases progressively as the frequency gets higher, giving less radio coverage. Added to this, the intensity of a wave varies inversely with the distance from a source. Optimum range is approximately 80km at VHF under the very best conditions (i.e. over salt water with no obstructions, ideal mounting, minimal losses, etc.). In practice such a range would regularly be achievable with higher gain antennas.

Troposphere is the lower part of the atmosphere, where temperature generally deceases with height. It extends from ground level to an altitude of about 9 km at the earths poles and 17 km at the equator. The height of the upper boundary also varies with daily atmospheric conditions. It is in the troposphere that changes of temperature, pressure and humidity, as well as cloud and rain, influence the way in which radio waves propagate from one point to another.

At frequencies above 30 MHz localized refractive index fluctuations in the troposphere can scatter radio energy. Also horizontally stratified abrupt changes in refractive index can cause reflection and extended negative gradients can cause ducting. All these mechanisms can carry energy far beyond the normal horizon and so give rise to interference between one radio path and another.

In addition, larger-scale changes of refractive index with height cause refraction (ray bending) of radio waves that can be quite significant at all frequencies at low elevation angles, especially in effectively extending the radio horizon distance beyond that of the optical horizon. Apart from this refractive index effect, radio propagation may be strongly influenced at frequencies above 3 GHz by the presence of heavy rain, and above 15 GHz the attenuation caused by oxygen and water vapour in the air becomes important, depending on the application. In addition, the absorption by rain and atmospheric gases will have an associated thermal noise emission. Attenuation due to rain arises from the absorption of the energy in the water droplets and from the scattering of energy out of the radio beam. The consequences of this raindrop size is that the attenuation for horizontally-polarised waves is greater than that for vertically polarised waves.

Radio waves are characterizes by either frequency or wavelength. The two are directly related, the wavelength is inversely proportional to the frequency. This means that when we increase the frequency, the wavelength gets shorter. The radio spectrum is split into several bands namely:

- Low Frequency (LF): 30-300 kHz
- Medium Frequency (MF): 300-3000 kHz
- High Frequency (HF): 3-30 MHz
- Very High Frequency (VHF): 30-300 MHz.
- Ultra High Frequency (UHF): 300-3000 MHz.
- Microwaves (MW): 3-30 GHz.
- Millimeter waves (MMW): 30-300 GHz.

The lowest bands (LF – HF) are used for broadcasting at high power. At these frequencies, the waves propagate along the ground and by bouncing off the ionosphere meaning waves at these frequencies can reach beyond the horizon. These bands are mostly used for voice and very slow data connections, and radio beacons.

Starting at the VHF bands, it becomes easier to shape the radio waves into beams , the available bandwidth is higher but the waves only reach as far as the horizon. This is because the waves penetrate the ionosphere and are not reflected back down again. Surrounding terrain, such as forests, hills and buildings begins affecting the waves, but in different ways. Microwaves are dispersed by heavy rain, and millimeter waves by both rain and fog.

As with HF communications, the capacity of an antenna to transmit and receive signals will vary considerably. A transmitting antenna will have all the power of the transmitter (less system losses) to radiate the signal. However, quality of reception will be subject to many environmental factors, not just the power of the transmitting antenna and where it is mounted.

Both the VHF and UHF direct wave are affected by multipath propagation created by reflection and scattering of the signal when it encounters obstacles like buildings, trees and the like. Signals affected by multipath effects arrive at the receiver later than those that are unobstructed and from different paths, resulting in fading and ghosting at worst case in total disruption of the signal.

It is always observed that the television signal reception in hilly areas (irregular terrain) usually suffers the problem of multiple image (ghosting) and noisy reception despite the long antenna used and hardly can those in the valley receive any signal. Since the wave in the high frequency range travel straight from the transmitter to the receiver, it is usually limited by the line of sight. The height of the transmitter antenna above sea level is equally very important, that is why most of the transmitting stations are usually cited on top of hills or high ground.

UHF signals are also far more subject to polarisation reversal due to topography than VHF signals with the result that unless the receive antenna can pick up both vertically and horizontally polarised signals, the received signal will suffer from flutter and fading.

Because the direct wave is longer at VHF frequencies, it has the ability to bend around obstacles through a process known as diffraction - to fill in around corners to some extent. However, as the frequency increases this ability diminishes progressively, and the size of the shadow zone where no signals reach becomes larger. As a result, a VHF network in a built-up area or a hilly terrain is often much more successful than one at UHF frequencies.

1.1. THE GEOGRAPHY OF IDANRE.

Idanre lies between Akure and Ondo Towns. Idanre falls within latitudes 9^0 8'N and longitude 5^0 5'E of the equator and Greenwich Meridian respectively. Its eastern neighbors are the Binis via Ofosun River which serves as boundary between Ondo and Edo state. To its west are the Ondos with land demarcated at Owena river. To its south are indigenes of Siluko (of old Bendel state), Onishere (Idanre tributary) and likale, also of Ondo state. Akure is, however,Idanre's neighbour to the north. The total land area is put at 619 square miles (1,584.6 km^2). The annual rainfall is put at about 70 inches, though with slight variations from year to year. Thick clouds envelopes the town during harmattan period. The humidity is more pronounced in the ancient Idanre town (Odode Idanre),whose altitude is about 1273 m above the sea level. For the most part of August and December each year, the peak of Orosun hill becomes almost invisible as haze perpetually engulfs it's topmost.

Nonetheless, between January and July, the temperature averages $78^{0}F$ and $83^{0}F$ respectively. Cool breeze reigns within this period. As such, humidity which is always very high in January is often catapulted to 80 per cent in July. Being a tropical region, the town has a large share of tall trees. The trees of this dense forest can be categorized into three:

The tallest trees which are distinguishable through their individuality and often about 45m in s height; next to these are trees between 23m and 3.6m tall, branches of which extend to one another thereby forming quasi expansive canopy; while the last and most common species of trees in this area are of hard wood. The trees in this group combine with those in others to form impenetrable forest, Samuel, (1991)

1.2. MOTIVATION

It is always observed that the radio wave (Television signal) reception in UHF frequency in mountainous (hilly) areas usually suffers the problem of ghosting, visual snow, periodic fading despite the height of antenna used. This usual problems and the possible solution on how the people in these areas could have a good reception form the basis of this research project.

1.3. OBJECTIVE OF THE RESEARCH WORK.

The specific objectives of this research are:

1. To observe the causes of ghost image on radio wave (TV signal) reception in mountainous terrain.
2. To establish a good radio wave reception system in these areas.
3. To recommend for the location of broadcasting station in mountainous environments.

1.4. SCOPE OF THE PROJECT.

This research project covers the following areas:

1 The study of the topography of Idanre.

2 The measurement of spot height of Idanre area to compare the results with that of the contour map of Idanre.

3 The spot measurements of signal field strength in the sighted areas on the map.

4 Analysis and discuss the results obtained and the possible solutions for good reception.

1.5. CONTRIBUTION TO KNOWLEDGE

The envisage-contributions to knowledge of the project are:

1 To reveal the causes of ghost image on the Television signal received in hilly areas.

2 The effect of high obstacles along the path of radio wave propagation (loss due to hi obstacles).

3 Revealing the effect that trees and foliage have on radio signal received in the for region.

1.6. M ETHODOLOGY.

The contour map of Idanre was obtained from the Ministry of Works, Land and Transport, Akure. From the map, the lines of sight distance from Ondo State Radiovission Corporation (OSRC) to the selected areas and the height of the obstructing hills were determined. Spot height above sea level measurements were taken with the aid of Global Positioning by Satellite (GPS) meter. Signal field strength measurements were carried out round the selected areas shown on the map using a professional TV signal field strength meter UNAOHM model EP742A.

CHAPTER TWO

2.0 RELATED THEORY

Consider an isotropic radiator in free space, which has equal radiation intensity in all directions. In free space, the resultant spherical wave spreads out with uniform intensity in all directions. If P_o is the power radiated by the isotropic source, the power density S at a radial distance r is the radiated power divided by the surface area of the surrounding imaginary sphere:

$$S = \frac{P_o}{4\pi r^2} \quad \text{w/m}^2 \qquad \text{------------------------ 2.1}$$

where: S is the Power density in W/m^2

P_o is the transmitted power in Watts

r is the radial distance in metre.

In the far field, power density S and electric field strength E are related by

$$S = \frac{E^2}{120\pi} \quad \text{V/m} \qquad \text{--2.2}$$

Where 120π is the intrinsic impedance of free space expressed in ohm and E is the electric field strength in V/m.

The electric field strength at a radial distance r is

$$E_o = \sqrt{\frac{30P_o}{r}\varepsilon^{-j\beta r}} \quad \text{V/m} \qquad \text{--------------------------------2.3}$$

Where the magnitude follows from (2) and (3) and where $\beta = 2\pi/\lambda$ is the free-space wave number or phase constant. (β is the space rate of decrease of the phase of the field in the direction of propagation). E_o denotes the free space field. The power density, S, falls off as $1/r^2$ while the electric field strength E_o falls off as $1/r$.

A communications signal may be subjected to loss due to the effects of trees, buildings or hills. A signal may also be affected by reflection from the ground or water. A reflected signal is often of different phase than the direct signal and therefore may either add to or subtract from it, resulting in fading and \or multipath transmission, which can result distortion, especially in FM systems .The effects of obstacle may sometimes be effectively eliminated by placing the receiver and the transmitter antenna at height that provide adequate terrain clearance which should be equal to or greater than the Fresnel clearance. A transmission path at a distance above level ground at least equal to the Fresnel clearance will minimize a multipath effect due to the ground.

Terrain effects that result in fading often may be minimized by a technique known as diversity. Space diversity utilizes two or more transmitting and or receiving antennas With sufficient physical separation so that if one link experiences a significant fade, the system can automatically switch to the other link. Frequency diversity accomplishes the same task by utilizing two transmitters at different frequencies. Polarization diversities takes advantage of the fact that a fade may be deeper for one antenna polarization than for another, and automatic switching is arranged to maximize the signal. Diversity systems are more complex and expensive than non-diversity systems, but their installation may often be justified in critical applications. In telecommunications systems where repeaters are used, the spacing specified will depend strongly upon the rainfall statistics for the system. Diversity, especially space diversity, is often used to combat the effects of heavy rainfall, Wilson, (1989).

2.1 RADIATION PATTERN OF AN ANTENNA.

An antenna radiation pattern or antenna pattern is defined as a graphical representation of a mathematical expression of the radiation properties of the antenna as a function of space coordinates. Radiation properties include power flux density, radiation intensity, field strength, directivity phase or polarization. The radiation property of most concern is the two or three-dimensional spatial distribution of radiated energy as a function of the observer's position along a path or surface of constant radius. A trace of the received power at a constant radius is called the power pattern. On the other hand, a graph of the spatial variation of the electric (or magnetic) field along a constant radius is called an amplitude field pattern.

2.2 FIELD REGIONS OF AN ANTENNA.

Why should we be concerned with the separation between the source antenna and the field strength meter, which has its own receiving antenna. One important reason is that if you place a receiving antenna very close to an antenna whose pattern you wish to measure, mutual coupling between the two antennas may actually alter the pattern you are try to measure.

This sort of mutual coupling can occur in the region very close to the antennas under test. This region is called the reactive near field region. The term reactive refers to the act that the mutual impedance between the transmitting and receiving antennas can be either capacitive or inductive in nature. The reactive near field is sometimes called the "induction field", meaning that the magnetic field usually is predominant over the electric field in this region. The antenna acts as though it were a rather large, lumped-constant inductor or capacitor, storing energy in the reactive near field rather than propagating it into space.

The strength of the reactive near field decreases in a complicated fashion as you increase the distance from the antenna. Beyond the reactive near field, the antenna's radiated field is divided into two other regions:- the radiating near field and the radiating far field. Historically. The terms Fresnel and FraunhÖfer fields have been used largely supplanted by the more descriptive terminology used here. Even inside the reactive near field region, both radiating and reactive fields co-exist, although the reactive field predominates very close to the antenna.

The space surrounding an antennas is usually subdivided into three region:

(a) reactive near-field

(b) radiating near-field (Fresnel) and

(c) far-field (FraunhÖfer) regions.

These regions are so designated to identify the structure in each. Although no abrupt changes in the field configurations are noted as the boundaries are crosses, there are distinct differences among them. The boundaries separating these regions are not unique, although various criteria have been established are commonly used to identify the regions.

Reactive near-field region is defined as "that portion of the near-field region immediately surrounding the antenna wherein the reactive field predominant. Radiating near-field (Fresnel) region is defined as "that region of the field of an antenna between the reactive near-field region and the far-field region wherein radiation field predominates and wherein the angular field distribution iş dependent upon the distance from the antenna. If the antenna has a maximum dimension that is not large compared to the wavelength, this region may not exist. For an antenna focused at infinity, the radiating near-field region is sometimes referred to as the Fresnel region on the basis of analogy to optical terminology.

Far-field (FraunhÖfer) region is defined as "that region of an antenna where the angular field distribution is essentially independent of the distance from the antenna. If the antenna has a maximum overall dimension D, the far-field region is commonly taken to exist at distances greater than $2D^2/\lambda$ from the antenna, λ being the wavelength, Balanis, (1989).

2.3 POLARIZATION OF AN ANTENNA.

Polarization of an antenna in a given direction is defined as the polarization of the wave transmitted (radiated) by the antenna. When the direction is not stated, the polarization is taken to be the polarization in the direction of the maximum gain. The polarization of a wave received by an antenna is defined as the polarization of a plane wave, incident from a given direction and having a given power flux density, which results in maximum available power at the antenna terminals.

2.4 PATH LOSS OVER HILLY TERRAIN

The propagation path loss for hilly areas is greater than that for none hilly areas. It therefore follows that the methods used to protect the signal strength of received transmission are more difficult in hilly areas than in none hilly areas.

The various shapes encountered in the contour of hilly terrain are unpredictably irregular. Often, the tops of intervening hills obstruct the direct line of sight path.

To properly analyze the path loss in hilly areas, it is necessary to classify hilly terrain into either one of two classic types that are described in terms of the physical characteristics of the propagation path.

Type 1 is the line – of- sight over hilly terrain where surface irregularities do not obstruct the direct signal path. Type 2 is the out- of- sight path over hilly terrain where surface irregularities project into and therefore obstruct the direct signal path.

In type 2, diffraction loss due to the obstruction hilltops of (the out- of –sight case) must be considered. Variations in the contour and roughness of the terrain, including any scatters that are present, cause changes in propagation as the result of specula reflection, diffuse reflection, and diffraction.

2.4.1 DIFFRACTION LOSS.

Propagation over hilly terrain is often adversely affected by obstructions such as hilltops. Path loss resulting from such obstruction is termed " diffraction loss". Kirchhoff's theory on diffraction has been found useful for predicting path loss along a transmission path containing mountain ridges and similar obstructions.

In classic electromagnetic theory application, the field strength of a diffracted radio wave associated with a knife-edge can be expressed as :

$$\frac{E}{E_o} = Fe^{j\Delta_\phi} \text{------------------------------} 2.4$$

Where E_o is the free space electromagnetic field in V/m with no knife-edge diffraction present,

F is the diffraction coefficient,

Δ_ϕ is the phase difference with respect to the path of the direct wave.

The loss due to diffraction is:

$$L_d = 20\log F \quad \text{dB.} \text{ --} 2.5$$

Where

$$F = \frac{S+0.5}{\sqrt{2}\sin\left(\Delta_{\phi} + \frac{\pi}{4}\right)} \quad \text{--2.6}$$

In the definition of F,

$$\Delta_{\phi} = \tan^{-1}\left(\frac{S+0.5}{C+0.5}\right) - \frac{\pi}{4}$$

And C and S are the Fresnel integral, expressed.

$$C = \int_0^v Cos\left(\frac{\pi}{2x^2}\right)dx \quad \text{-----------------------------------2.7}$$

$$S = \int_0^v Sin\left(\frac{\pi}{2x^2}\right)dx \quad \text{-----------------------------------2.8}$$

Where v is a dimensionless parameter, defined:

$$V = h_p\sqrt{\frac{2}{\lambda}\left(\frac{1}{r_1} + \frac{1}{r_2}\right)} \quad \text{--2.9}$$

In eq (9), r_1 and r_2 are the separation distances, and h_p is the height of the knife edge shown in fig2. 1. In predicting the effects of knife-edge diffraction, it is necessary to consider the two possible situations:

(i) Where the wave is not obstructed.

(ii) Where the wave is diffracted by the knife-edge obstruction, Lee, (1982)

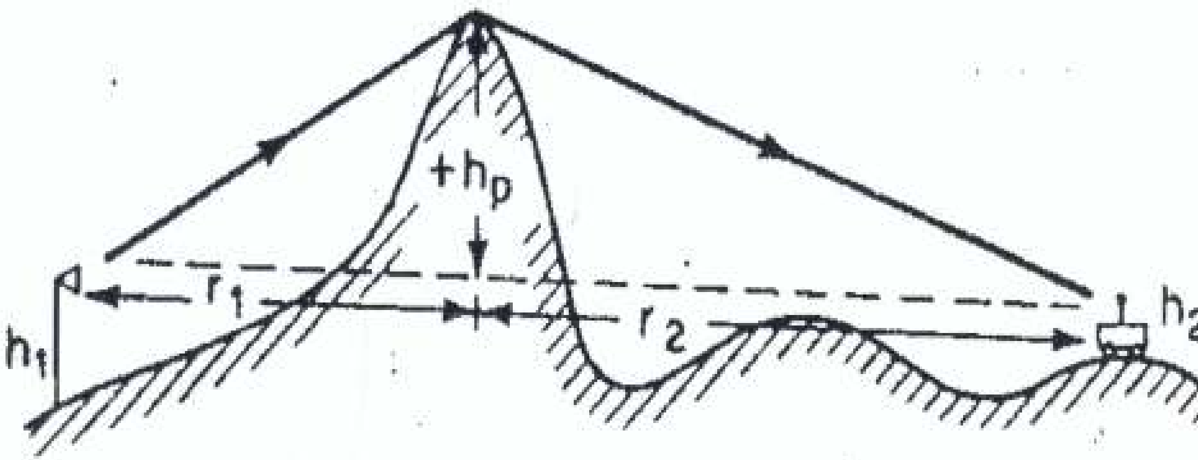


Fig.2.1 Knife Edge diffraction.

2.5 FIELD STRENGTH BEYOND THE HORIZON

When the horizon or any other obstacle intercepts the direct waves, the signal may be propagated beyond it by diffraction. Diffraction occurs when the incident energy falling tangentially on the rim of the obstacle to radiated from the absorbing points on the rim. Since the source of re-radiation is at or near the surface, the radio wave suffers high attenuation increases rapidly with frequency. Thus while the field strength within the horizon distance decreases as the square of the distance, beyond the horizon the field strength decreases at a much higher power. The exponent varies from the inverse fourth power at about 50 MHz to the inverse tenth power at about 500 MHz.

The field strength E_h beyond the horizon may be computed approximately by the following relation:

$$E_h = \left(\frac{d_h}{d}\right)^N \quad \text{--2.10}$$

Where

E_h is the field strength at the horizon computed by the usual equation.

d_h is the distance to the horizon.

d is the distance to the receiving point beyond the horizon. Then,

$$E_h = \frac{88\sqrt{P}h_r h_t d_h^{\ N-2}}{\lambda d^2} \text{ volts/meter} \quad \text{-----------------------------------2.11}$$

Where P is in watts, h_r, h_t is in metre, d_h, d are in Km and f is the frequency in MHz, Mithal and Mittal, (1964).

2.6. The Effect of Trees on Television Reception

Many Local Authorities, local amenity and conservation societies and householders are planting trees which, if carefully positioned, can enhance an area. However, few people are aware of the effect trees can have on the reception of television broadcasts - particularly those using analogue systems. The greatest effect of trees tends to be on the higher frequencies.

Evergreen trees have more effect on television signals than deciduous trees, and experience suggests that coniferous trees are worse than broad-leaved evergreens. In winter, when deciduous trees are bare, they have very little effect compared with summer when the same trees are in full leaf. During wet weather, when covered in moisture, all trees can have an appreciable effect on signals. As trees sway in windy weather the screening effect varies, leading to fluctuations in the quality of reception. When the surrounding trees are below the level of the rooftop, there should be no problem, provided that an adequate roof-mounted UHF aerial of the correct type is used. Where trees are above the level of the rooftop it may be necessary to install aerials so that they are above the trees. This can sometimes be achieved by mounting the aerial on a pole attached to the chimneystack or by using a remote aerial clear of the trees. The problem is more difficult for people who live in single-storey houses. However, it is sometimes possible to site a receiving aerial so that it is below the main branches of the trees. If there are no other obstructions at low level, then satisfactory reception may result. When deciding the height of an aerial, allowance should be made for growth of the tree. If the aerial cannot be mounted above the tops of the trees, the signal will inevitably be weakened in passing through the trees. This is not necessarily disastrous but it may involve the use of a high-gain aerial, possibly with a masthead amplifier. In any case it is desirable to use a good quality low-loss feeder to connect the aerial to the receiver, and it will often be advantageous to try an alternative position for the aerial on a different chimney stack for instance, BBC,(2002).

The work of Saxton and Lane (1955) and Sofaer and Bell (1966) leads to a figure of 0.2dB per meter at UHF for attenuation through trees, and ignoring differences due to polarization and season should not lead to errors of more than 4dB. However, for a certain depth of trees, the largest signal will be received by diffraction loss caused by a clump of trees at say, 1 Km from a receiver at about 40dB diffraction will be the dominant mechanism if the trees are more than 50meters deep.

Many authors have investigated radio-wave propagation in forested environments, and their studies of propagation conditions reveal that the presence of vegetation produces a constant loss, independent of distance, between communication terminals that are spaced 1 Km or more apart. Since the density of foliage and the heights of trees are not uniformly distributed in a forested environment the results are not surprising. Tamir measured the signal loss due to foliation at a distance of 1 Km, with both the transmitting and receiving antennas at tree top heights. Tamir also made a theoretical prediction that the loss increases as the frequency increases. His studies also indicate that the signal loss for vertically polarized waves is slightly greater than for horizontally polarized waves in areas with dense foliage, Tamir, (.1977).

In Fig2. 2, the measurement made by Rendick and Wazowicz, with one antenna clear of the tree tops and the other antenna completely immersed in vegetation, shows that under this condition losses were more than those measured by Tamir, except at one point, Rendick, (1973).

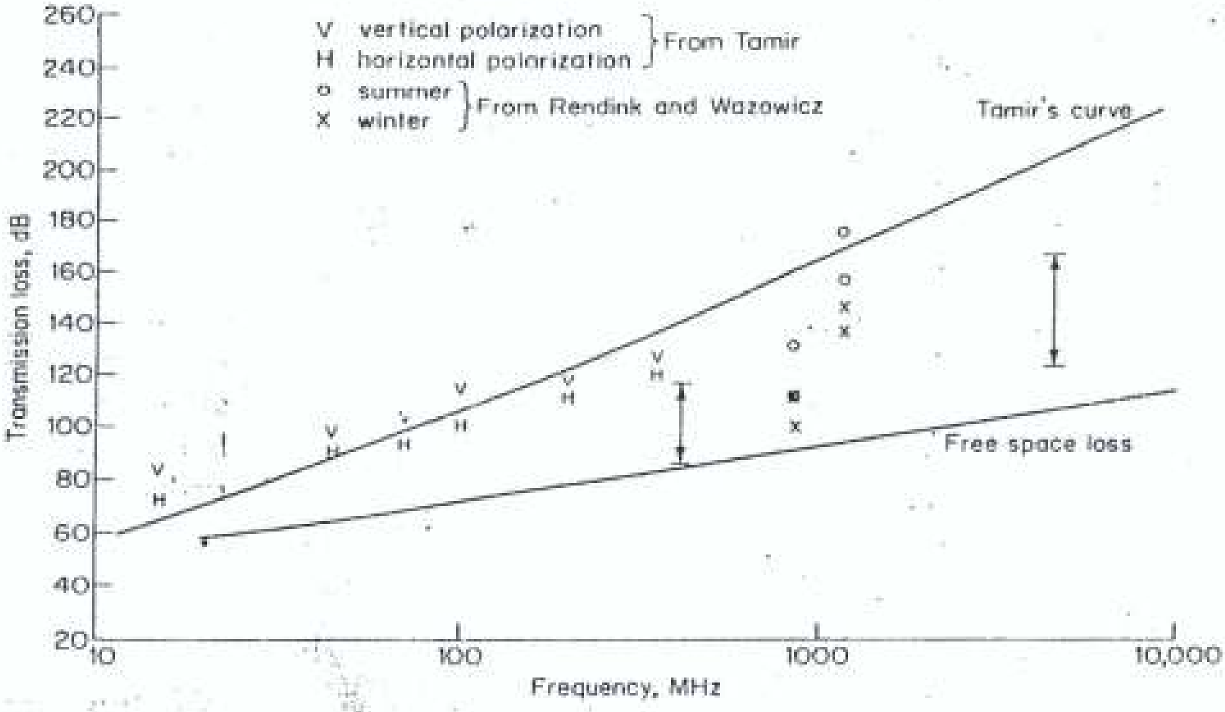


Fig.2.2 Signal loss due to the effect of foliage.

2.7 PROPAGATION OF TELEVISION SIGNALS

Television broadcast is done in VHF and UHF bands because of the large bandwidth requirements of 7 MHz per channel. At such high frequencies, tropospheric or space wave propagation is used. Surface wave propagation cannot be used because at such frequencies, the signal die down after having travelled a small distance due to large attenuation offered by ground. Similarly, sky wave or ionosphere propagation is not possible since at such frequencies, the radio waves penetrate through the ionosperic layer and do not come back to the earth.

2.7.1 RANGE OF TELEVISION SIGNAL USING SPACE WAVE PROPAGATION.

In general, the range of television signal is limited up to or slightly beyond the line of sight distance. This line of sight distance is the sum of the radio horizon distance to the transmitting and receiving antennas. The line of sight range of television signals using space wave propagation is given by:

$$D = 1.968\left(\sqrt{h_r} + \sqrt{h_t}\right) \text{ km} \qquad \text{------------------------------2.12}$$

Where h_t and h_r are the heights of transmitting and receiving antennas respectively and they are in metre.

2.7.2 EFFECT OF EARTH'S CURVATURE ON TV SIGNALS.

The curvature of the earth produces the following two effects on the TV signals:

(i) It reduces the difference in the path lengths between the direct and the ground reflected components by raising the point of reflection above that of a plane earth and as a result tends to reduce the strength of the received field.

(ii) Curvature of the earth causes the reflection at the ground to take place from a spherical rather than a flat surface thereby making the reflected components divergent and hence cause it to become weaker at the receiving point. This tends to increase the resultant field strength.

These two opposite effects produced by the earth's curvature almost neutralize each other. As a result, the assumption of plane earth fields result which remain valid in spite of considerable curvature of earth.

2.8 FIELD STRENGTH IN THE SHADOW ZONE.

According to geometrical optics the field strength below the line of sight or tangent Ray is zero. However, Mithal and Ravil Mittal suggested that because of diffraction effects the radiated field penetrates into the shadow zone below the tangent ray.

The findings in this exercise shows that field strength decreases rapidly as the point of observation moves deeper into the shadow zone. Hills and large buildings obstruct the space wave TV signals and cause shadow zones as shown in Fig.2.3. Diffraction of TV signals at hill top A permits reception in shadow zone beyond point B. This still leaves a large shadow zone shown shaded in Fig.2.3.

This region receives no TV signal. The problem may be overdone by erecting a Yagi antenna at the hill top as shown in Fig.2.3. and ruining a coaxial cable from the antenna feeding a number of TV receiving stations in the shadow zone. This antenna thus serves as a community antenna, Mithal, (1964).

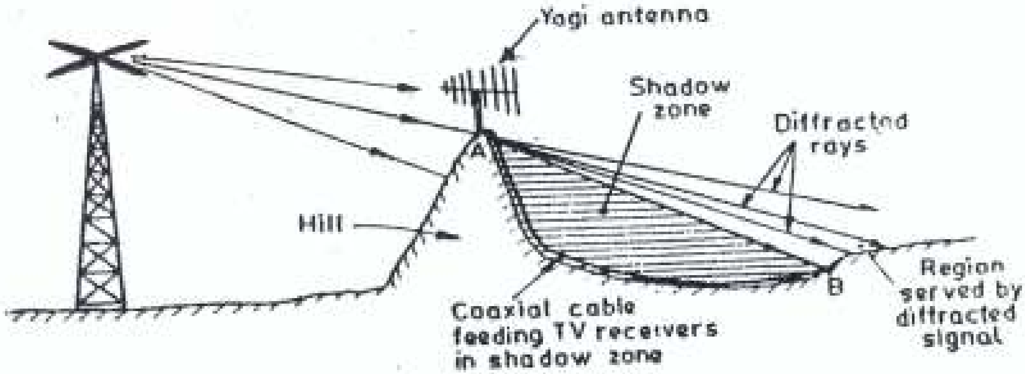


Fig. 2.3(a) Reception in the shadow region

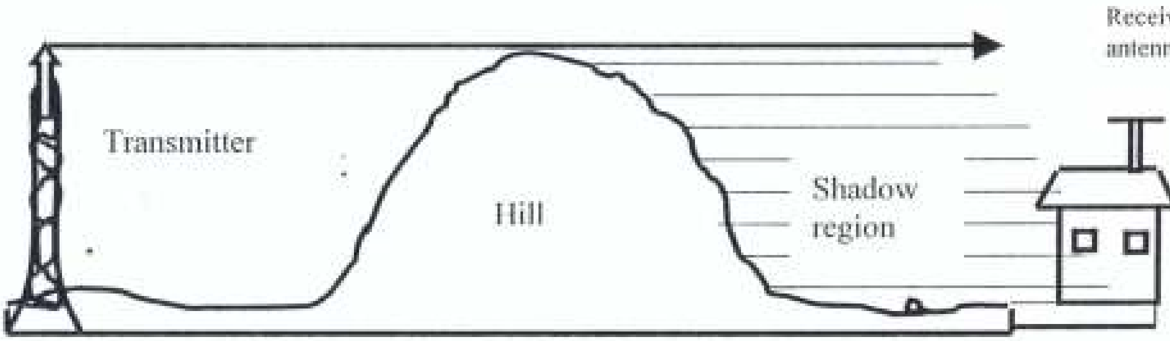


Fig.2.3(b) Receiver in the shadow of a hill.

3.0 MECHANISMS THAT CREATE TELEVISION RECEPTION PROBLEMS.

Hills along the path of propagation produce two zones of potential disruption to television reception. One zone is where the development creates a 'shadow' and the other where it gives rise to a 'reflection'.

3.1 SHADOWING EFFECTS.

UHF transmissions closely resemble those of light waves. As with light, objects such as hills, buildings, or tall trees can obstruct or deflect the UHF signals, creating deep shadow patterns in which reception is difficult. The screening effect of trees has a further disadvantage in that it can vary greatly with the season and weather conditions, and is especially important in areas where television signals are weak. In strong signal areas, it is often possible to accept some attenuation from trees and still obtain a satisfactory picture.

In an area behind the structure, the television transmitter is effectively screened from the viewer and the strength of the signal is reduced. Television signals received in a shadow zone could be divided into this three sub-zones:

1. Within a few tens of metres from the hills, over the region where optical view of the transmitter is lost, the reduction in signal strength is critically dependent on the specific height and size of the hills.
2. Further away from the hills (say beyond 250 m, but this varies depending on its size) the limit of the shadow zone and the signal reduction are determined by diffraction at the edges of the hills and reflection off surrounding hills. The condition of whether or not a location has an optical view of the transmitter is not

enough to classify the potential interference zone adequately. In general, the effect is that the signal appears to bend around the sides of the hills; the shadow zone reduces in size and he signal strength is reduced by much less than simple ray optics would suggest.

3. Even further away from the hills (say 5 km) complex multiple reflections and diffraction, caused by hills in the locality, may result in the shadow zone becoming almost non-existent.

3.2 REFLECTION EFFECTS.

The second zone of potential interference is produced by reflection or scattering of the incident signal. Even though television signals travel at the speed of light, the different path lengths can mean that one signal arrives with a significant delay relative to the other.

This results in a second image appearing on the viewer's screen displaced from the first. This type of interference is known as 'delayed image' or, 'ghosting'. If the reflecting signal is complex, several such ghost images can result.

The general location of the 'reflection' zone depends on the angle of the incoming signal and the orientation of the hills. The extent of the zone and degree of interference within the zone depend on the relative strengths of the direct signal and the reflected signal, determined by the radio-frequency reflectivity of the hills, and also on the delay between the two signal. The greater the relative strength of the reflected signal, and the longer the delay, the more subjectively intrusive this problem becomes.

Another factor which significantly affects the size and shape of the 'scattered' or 'reflected' interference zone is the radiation pattern of the viewer's receiving aerial. Consider a location where the delayed signal has a relative amplitude and delay consistent with unacceptable interference. If the angle between the source of the direct signal and the source of the delayed signal greater than about 45^0, an aerial whose pointing is optimized to receive the direct signal will discriminate against the delayed signal. For critical applications, a very narrow beamwidth aerial may be used to reduce the strengths of delayed images to acceptable levels as shown in the Fig. 3.1.

3.3 GHOSTING

"Ghosting" is the effect you see when several identical images seem to be superimposed on each other. This is a sign that the signal is arriving at the aerial from two or more directions at the same time, because the original signal has been reflected randomly off local buildings, trees and terrain. The technical term for this is ''multipath''. If the images you see superimposed on each other are different, it means that the TV is picking up signals from other channels. This is "Co-channel interference''.

If ghosting is caused by a single structure that creates one distinct ghost image, a medium or large multi-directional antenna may be useful with careful positioning to eliminate the reflected signal. However, the antenna may require different positioning for each channel. Directional antennas are the most ghost-resistant antennas since they "see" in only one direction and have a tendency not to see the reflected ghost signal. The further away from structures the antenna is located the less likely a problem will occur. Many factors, however, such as the structure's total surface area, the direction it faces, and neighborhood terrain, will influence how much effect the structure will have on TV reception.

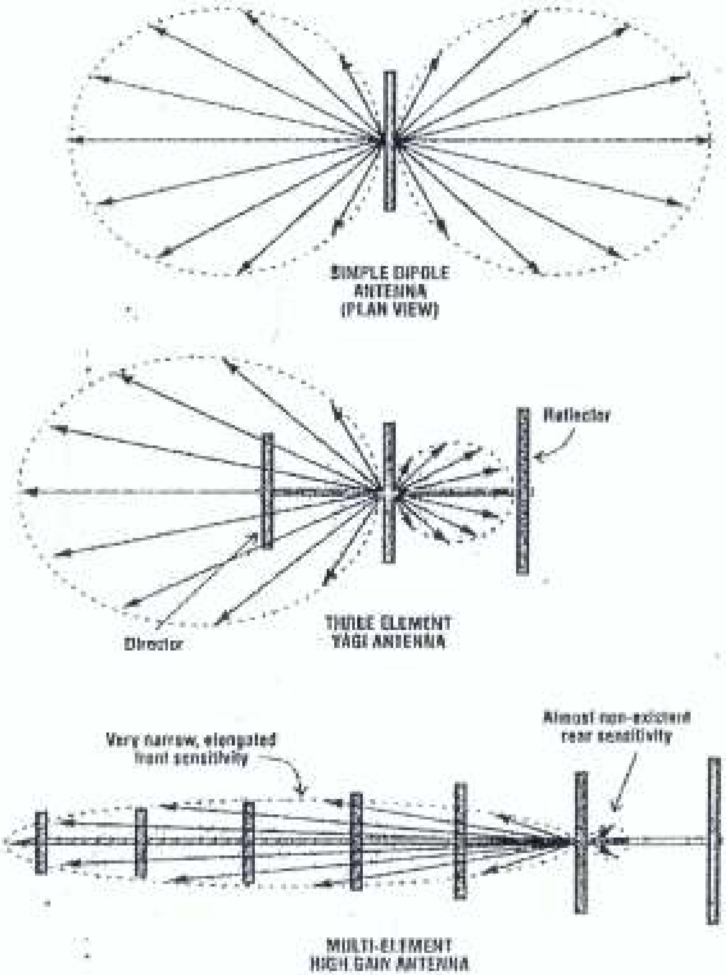


Fig. 3.1. Typical Wide and Narrow Beam-Width aerial Radiation pattern.

3.3.1. GHOST IMAGES.

Television signals may also reach the TV receiver by a longer path after reflection from a large object such as huge buildings, hills etc. This unwanted signal arrives a little later than the desired signal reaching directly and produces another `image on TV receiver slightly displaced horizontally from the desired image. This displacement is proportional to the line delay between the two paths.

The ghost picture has much less contrast than the main picture since the ghost signal is weak. If the path difference is small, no separate ghost picture may appear but the main picture may simply appear fuzzy.

3.3.2. MULTIPLE GHOST.

Using simple dipole receiving antenna, several tall buildings in the strong signal path may cause multiple reflections and hence appearance of a series of ghost. However, use of suitably mounted directive receiving antenna rejects these reflected signals and pick up the direct ray only, thus eliminating the ghost signals. Sometimes the ghost picture is negative due to the reversal of phase of the reflected signal.

3.3.3. LEADING GHOST.

In case of TV receivers located in clash vicinity of the TV transmitter, with imperfectly balanced input circuit, direct pick up of TV signal by the receiver input circuit. The antenna feeder or power supply leads produces a leading ghost i.e. a ghost image to the left of the main picture. Such a leading ghóst may be eliminated by:

(i) Shielding receiver to avoid pick up.

(ii) Placing suitable R.F filter in the power supply led by passing the power supply lead pick up.

(iii) By using balanced input circuit in the television receiver.

By using a shielding coaxial cable feeder in place of an open twin wire feeder

3.4. SUBJECTIVE IMPACT GHOSTING

For an acceptable picture, the maximum permissible strength of the 'reflected' signal relative to the direct signal (known as the 'protection ratio') varies according to the length of the delay. The International Telecommunication Union is the organization responsible for world radio standards, and ITU-R Report 478-1 contains the following results obtained experimentally.

Table 3.1 ITU-R Subjective impact ghosting standards.

Impairment Grade ITU-R	Protection ratio (dB) for delay:	Protection ratio (dB) for delay:	Protection ratio (dB) for delay:
	0.4 μs*	0.8 μs*	1.4 μs*
	18	26	30
	12	18	20

* Note that 0.4μs, 0.8μs and 1.4μs correspond approximately to the 'ghost' being offset to the right from the main picture by 3 mm, 7 mm and 12 mm on a screen of a television set which is 50 cm (20 inches) wide. BBC , (2002).

3.5. REDUCTION OF IMPACT.

The 'shadow' region, of any solid structure is mainly determined by its size. Very little can be done, either at the design stage or after development, to reduce these effects themselves, but the damage done can sometimes be 'man-good' by providing those affected with an alternative means of receiving television.

The 'reflected' interference region is entirely dependent on the terrain. If the face of a hill is shaped so that it distributes its reflected signal over large region, the resulting reflected signal strength is less than if it were concentrated over a small region.

A large area of structure presenting a single flat face will concentrate signals over a small region. The same area consisting of several smaller flat faces at differing angles will distribute the signals over as many geographical regions. A convex reflecting surface will disperse signals equally over an arc.

In practice, the avoidance of large flat areas is the best overall approach. The deliberate dispersion of signals by non-flat services, or the direction of reflected signals away from populated areas, are the best ways of avoiding significant 'ghosting' problems.

3.6. COMMON RECEPTION PROBLEMS

3.6.1. Visual Snow

'Snow' is visual noise caused by a weak signal. It looks a little like the grain of an under exposed or over enlarged photograph. The receiver either needs to receive a stronger signal or it has lost sensitivity. If the signal has become weak recently, check that the transmitter is not using reduced power while undergoing maintenance and check the cables and aerial.

3.6.2 Sparkles

Sparkles, appearing as small regularly spaced white dots, are often caused by arcing. For example, a thermostat or poorly suppressed car ignition causes wide band interference that can also be heard on radio receivers. A similar effect with black and white dots or short randomly spaced lines often appears on analogue satellite receivers when the signal is weak. The signal may be weak owing to heavy rain, or there could be a problem with the dish.

3.6.3 Ghosting or multiple images

"Ghosting" is the effect you see when several identical images seem to be superimposed on each other. This is a sign that the signal is arriving at the aerial from two or more directions at the same time, because the original signal has been reflected randomly off local buildings, trees and terrain. The technical term for this is "multipath'' If the images you see superimposed on each other are different, it means that the TV is picking up signals from other channels. This is "CO-channel interference". Overloaded amplifiers or miss-tuned VCRs and satellite receivers can cause a similar effect - this is called "intermodulation".

If ghosting is caused by a single structure that creates one distinct ghost image, a medium or large multi-directional antenna may be useful with careful positioning to eliminate the reflected signal. However, the antenna may require different positioning for each channel. Directional antennas are the most ghost-resistant antennas since they "see" in only one direction and have a tendency not to see the reflected ghost signal. The further away from structures the antenna is located the less likely a problem will occur. Many factors, however, such as the structure's total surface area, the direction it faces, and neighborhood terrain, will influence how much effect the structure will have on TV reception.

3.6.4. Periodic fading

For some paths between transmitter and receiver, the signal level can vary greatly over time. Usually this happens on long paths or those that pass over some obstruction, for example a hill where the signal is being received by diffraction. It may also occur in coastal regions where strong reflections from the sea alternately add and subtract with the direct signal difference. The effect is a slow variation in signal strength over time from weak to strong and back again. The most effective solution to this problem is to use two aerials, spaced vertically, Radio Communications Research Unit at the Rutherford Appleton Laboratory (2000)

3.7 ELECTROMAGNETIC INTERFERENCE (EMI).

This is also known as radio frequency interference, like multipath reception, EMI is another example of reception of the signals from the TV station(s) being disturbed by other signals picked up by the antenna. But instead of the extra signals being reflected and delayed versions of the main signal, in this case they are from a different source of radio waves altogether. They might be coming from an industrial heater or welder; or a medical diathermy machine; or a nearby computer; or sparking from a big motor drive system (for lift or elevators)., power tools or appliance motors; or from corona discharge from high-voltage power lines; or radiation from a commercial two-way radio transmitter. They might even be from an FM station or another TV transmitter on either the same channel as the local station or an adjoining channel, whose signal are still able to reach your antenna with sufficient strength to cause interference.

EMI from FM broadcasting transmitters, industrial heaters, diathermy machines and computers tends to cause moving coloured lines or patterns superimposed on the picture, and again disturbing its clarity, the coloured lines are usually slanted but they can be at any angle between horizontal and vertical and sloping either way. They can also be in a variety of colours, depending on the exact frequency of the EMI signal compared to the signal from the TV station.

Some signals from radio transmitters and similar sources of EMI can also produce audible interference, if they are strong enough. This takes the form of beat tones or 'whistles', or garbled and distorted speech, along with the TV programme sound.

EMI from noise sources like sparking motors or corona discharge from power lines tend to produce horizontal lines or bands of 'sparkling' noise superimposed on the picture. The noise bands are often fairly fixed in position vertically, but they may move slowly up or down.

Interference from another TV station on the same channel is easy to recognize: like ghosting it manifests as another picture on the screen, but in this case it is not the same picture shifted to the right, but a different picture altogether. In almost every case it is not fixed in position either, instead it moves slowly from left to right or vice-versa.

Also a problem of signal overload due occurs, this is a situation whereby one or more of the TV signals reaching the set from the antenna are simply too strong. This can cause the radio receiver part of the TV set to distort the signals itself, and make them interfere with each other as a result. The symptoms of overload can be negative and unstable pictures, picture 'tearing', lines and patterns across the picture (very similar to other kinds of EMI), other images moving across the picture watching, and/or distorted sound. These are the sorts of problems tend to get if receiver is very close to TV station's tower, or very near another high powered transmitter.

CHAPTER FOUR

4.0 METHODOLOGY

The contour map of Idanre was obtained from the Ministry of Works, Land and Transport, Akure. From the map, the lines of sight distance from Ondo State Radiovission Corporation (OSRC) to the selected areas and the height of the obstructing hills were determined. Spot height above sea level measurements were taken with the aid of Global Positioning by Satellite (GPS) meter. Thogh there were little different (about±2.5 m) in the direct measurement and the contour lines indicated on the topographical map of Idanre. The topographical map was used where the spot height could not be assessed like the tall hills at Odode-Idanre. Also, the height of the transmitting antenna was obtained from Ondo State Radiovision Corporation (OSRC).

Signal field strength measurements were carried out round the selected areas shown on the map using a professional TV signal field strength meter UNAOHM model EP742A. Then, Fourier analysis method is used to analyse the results obtained to show the impact of multipath and reflection on the signal field strength received each locations.

4.1. THE MODEL

The field strength varies inversely as the square of the distance.

The free space field strength is given by

$$E_f = \frac{7\sqrt{P}\,4\pi h_t h_r}{\lambda d^2} \quad \text{volts/meters.}$$

$$E_f = \frac{88\sqrt{P}\,h_t h_r}{\lambda d^2} \quad \text{volts / meter} \ldots\ldots 2.13$$

Where h_r = height of the receiving antenna in metres

h_t = height of the transmitting antenna in metres

P = Transmitted power in watts

λ = Wave length of the frequency transmitted in metres.

d = distance between the transmitter and the receiver in metres.

4.2. THE DIRECT MEASUREMENT

The measurements were carried out round the sighted areas shown on the topographical map of Idanre compiled and drawn by Federal Survey, Nigeria, obtained from Ondo state ministry of Works, Land and Transport, Akure. These measurements were carried out between the month of January and February when there were little leafs on the trees and it was between 8.00 am and 12.00 pm each day. Series of these measurements were carried out using the appropriate field strength meter.

4.3. MEASUREMENT INSTRUMENTATION.

A yagi array receiving antennae covering both VHF and UHF frequency bands was used measurements. This was mounted on support about eight metre above the ground to prevent adverse effect the ground might have on the reception, and positioned away from tall building hills. It was also positioned towards the hills (where there are hills) to see the effect it has on video signal. The Yagi array was coupled through a 50-ohm feeder to a UNAOHM TV strength m type EP742A, designed for monitoring and measuring TV broadcast signals (vision and audio), in VHF/UHF Bands I, III, IV and V.

The EP742A field strength meter is a high-quality and full-function instrument which is capable of providing every useful information for planning and carrying out the best installation of the receiving and distribution systems out of the actual reception conditions of the selected area and out of system requirements (in terms of distribution points, channels to be distributed, attenuation, amplification, filtering and channel conversion).

With EP742A the following could be performed:

1. Investigate the spectrum by means of the full (band) control for an immediate visual evaluation of the carriers available in the selected area and the Expansion control for an in-depth analysis of a portion of the spectrum, down to almost a single channel.

2. Identify the channel under investigation using the TV picture monitor control and evaluate the quality of the received signal using also the zoom and sync pulse controls (interferences, reflections, disturbances and noise).

3. measurement of the strength of the video carrier of the channel so identified using the dB controls. It can also measure the strength of the audio carrier.

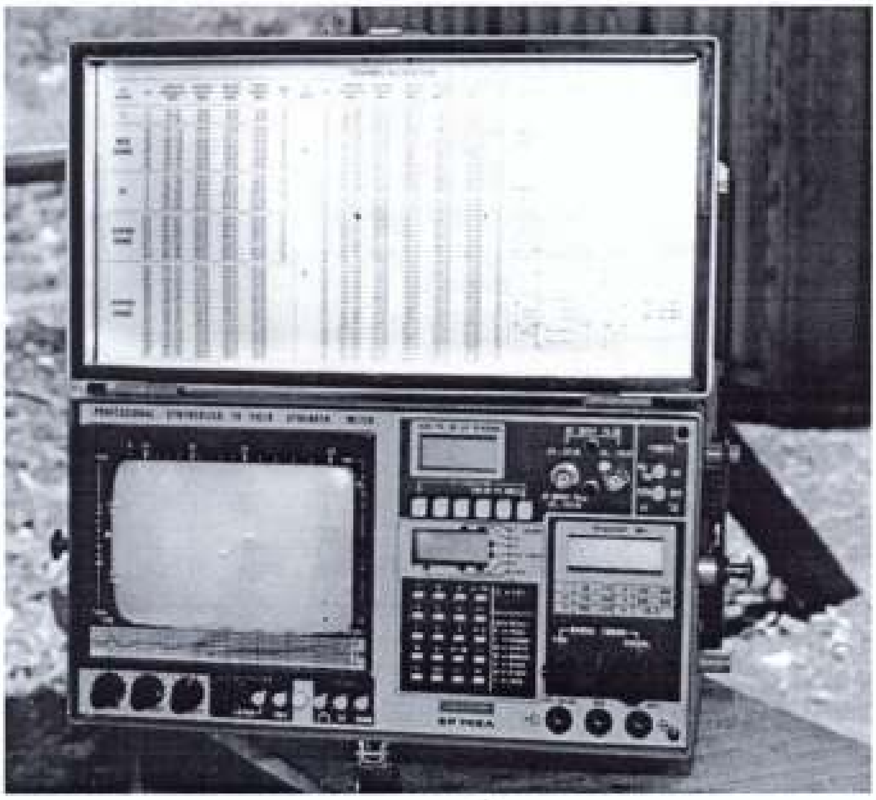


Plate 4. 1   The Professional TV Field Strength Meter UNAOHM model EP742A

4.4. TRANSMISSION CHARACTERISTICS.

The measurements carried out were based on the signal radiated from ondo state radio vision corporation (OSRC) transmitting station at Orita obele in Akure with the characteristics specified below:

Location	Orita Obele, along Ijare Town, Akure. (Longitude 5.2^0E, Latitude 7.3^0N)
Channel	23 at UHF Band.
Frequency (vision)	487.25 MHz
Frequency (sound)	492.75 MHz
Polarization	Horizontal
Azimuth pattern	Peanut
Beam Tilt	0.75^0
Transmitted Power	18 kW
Power gain	1.92 (2.83 dB)
Horizontal gain in main vertical lobe	30
Directional gain	31.92
Transmitting Aerial	Andrews ATW series
Height of location above sea level	413 m
Height of antenna	244 m
Total Height above sea level	413 + 244 = 657 m

CHARPTER FIVE

5.0 RESULTS AND ANALYSIS

5.1 FIELD STRENGTH MEASUREMENT.

Tables 5.1-5.4 indicated below show the results obtained from spot measurement carried out with the field strength meter at different locations identified on the topographical map of Idanre. The signal received by the field strength meter at locations round the hilly terrain varied with variation in terrain contour.

Table 5.1 covers the measurements taken in the areas where there are no high obstructions between the transmitter and the receiver (from Ogburugburu to Oke Agunla). These fall on the side before the obstructions as shown on Fig. 5.1. The graphical representation of the results obtained in Fig. 5.5a and Fig.5.5b shows that there is linear reduction in the signal received as the line of sight distance increases except at Oke Agunla of height above other locations.

Table 5.2 indicates the measurements taken in the main town of Odode Idanre which is surrounded by high hills, this town could be described as a town in a valley. Fig. 5.2 shows the area of a shadow zone. The signals obtained here are highly affected by mountains. It could be said that the propagation here suffered some reflection and diffraction which caused images on their reception. The graphical analysis of the results reveal that instead of linear decreas with distance, this gives a fluctuation (zig-zag) graph of Fig. 5.6a and Fig.5.6b which shows the effect of the hills present in the path of propagation. Though

Idanre falls within the primary coverage area and the signal received here should be up to 60 dB (1 mV/m).

Table 5.3 covers the signal field strength measured in the areas which fall behind the hills (hills in between the transmitter and the receiver) of Odode Idanre but some kilometers away from these hills. This stretches from Apefon to Igbo-Epo as shown on Fig 5.3. The table shows that clear signals were received at these points because the diffracted signals from the hills at Odode Idanre could be received here. It could be seen from the graphical analysis of Fig.5.7a and Fig.5.7b that there is no linear increase as one move away from the hill (shadow region) due to the topography of the area.

Table 5.4 covers the signal field strength measured in the areas, which are partly obstructed by hills and partly by thick forest, stretching from Akolo to Eripose as shown on Fig. 5.7. The results are shown graphically in Fig.5.8a and Fig.5.8b which shows a little fluctuation due to the presence of little foliage.

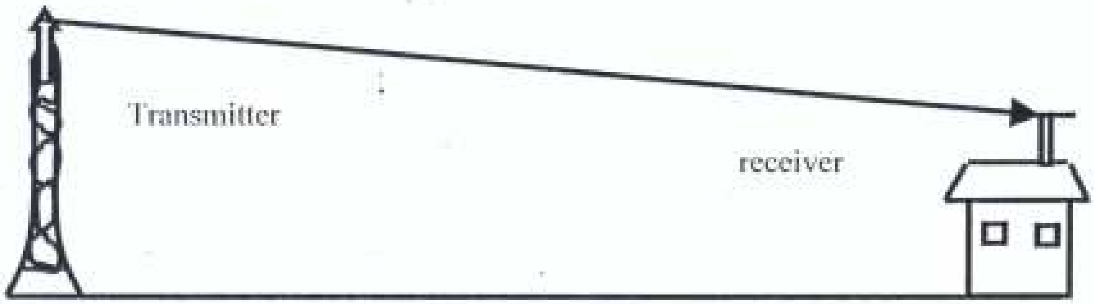


Fig. 5.1 Reception before the mountains (Ogburugburu to Oke Agunla)

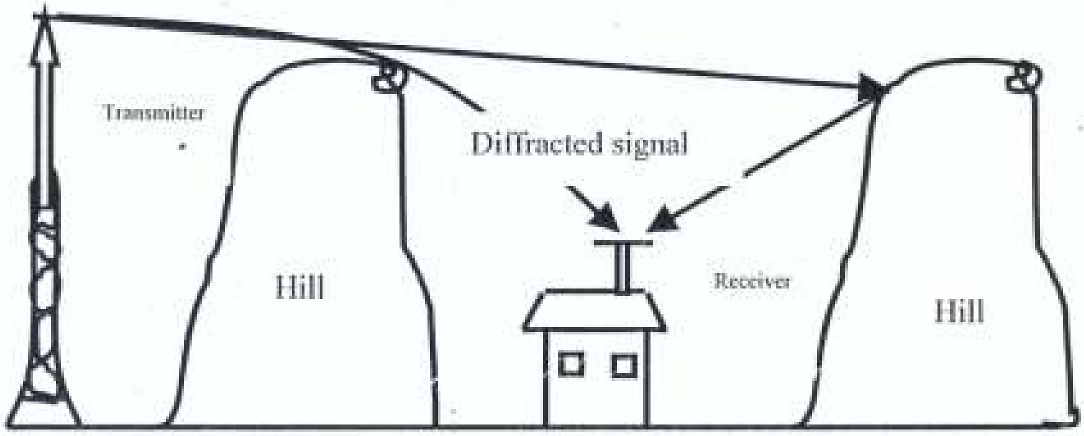


Fig. 5.2 Reception at the main town of Idanre, the signal received is both diffracted and reflected signals.

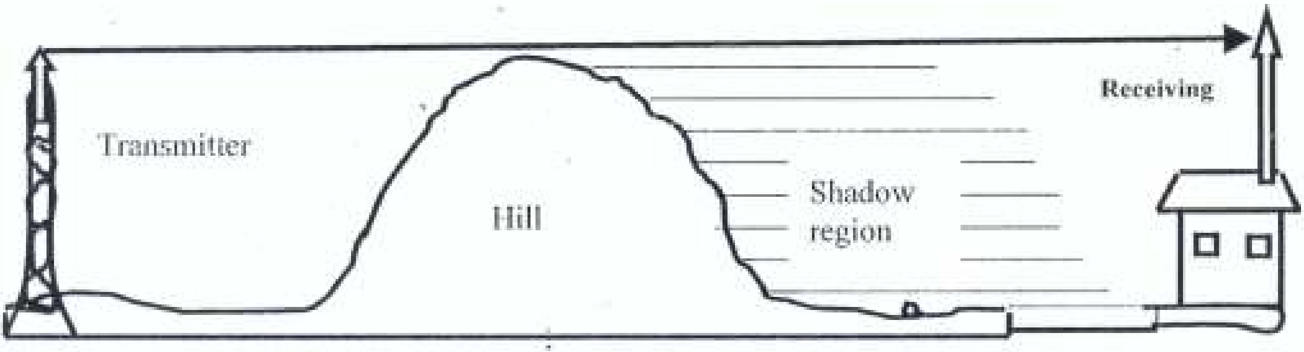


Fig. 5.3 Reception after the mountains, from Apefon to Igbo-Epo.

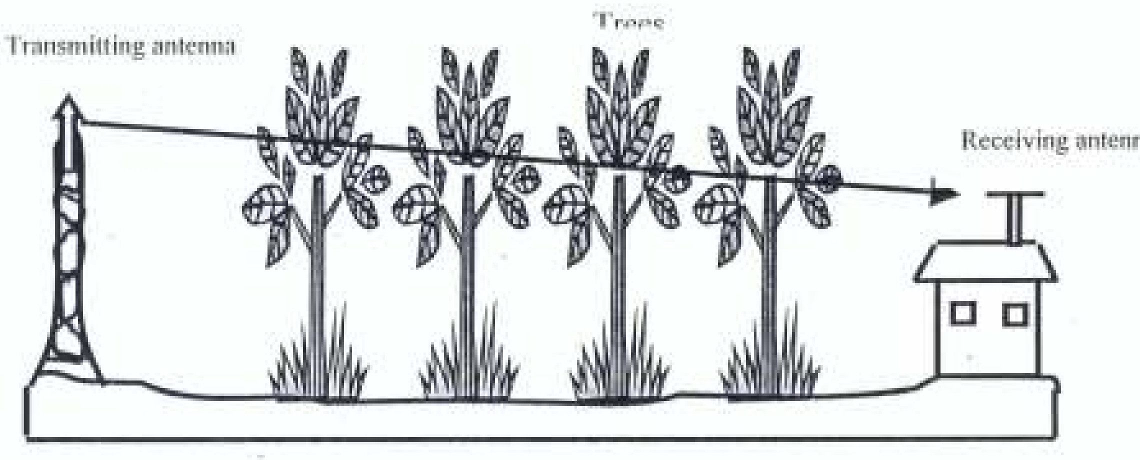


Fig. 5.4 Reception in the forest region of Idanre, from Akolo to Eripose.

5.2 RESULTS.

Table 5.1. Field Strength Signal Measured before Idanre.

S/N	Identified Towns	Line of sight distance from transmitter (km)	Field strength (dB)	Field strength (mV/m)	Path loss in dB.	Height above sea level.(m)	Nature of signal	Nature of terrain
1	Ogburugburu	2.75	94.00	50	1	303	Clear	Clear Line of Sight
2	Adofure	6.50	89.00	28	6	288	Clear	,,
3	Ita-Olorun	11.00	86.00	19.95	9	288	Clear	,,
4	Youth Center-Alade	15.25	64.00	1.58	31	288	Clear	,,
5	Oke-Agunla. Alade	16.50.	69.00	2.82	26	303	Clear	,,

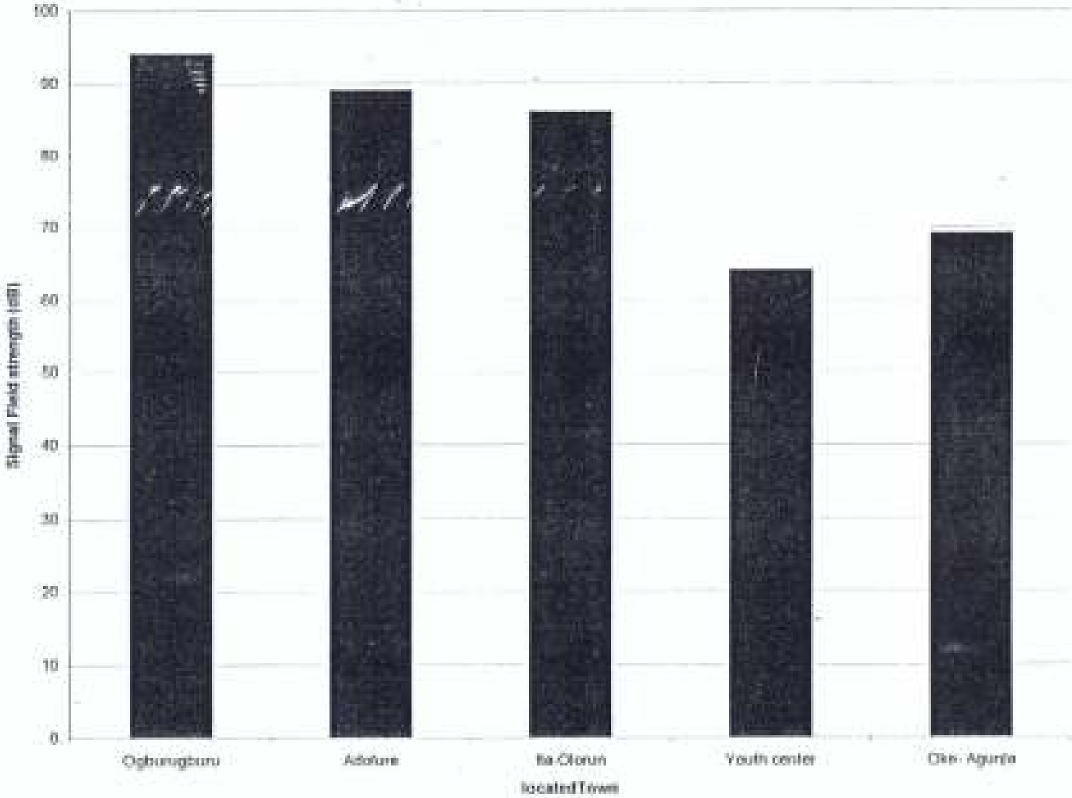


Fig. 5.5a The bar chart showing the signal field strength measured at the specific locations from Ogburugburu in Akure to Oke-Agunla , Alade.)

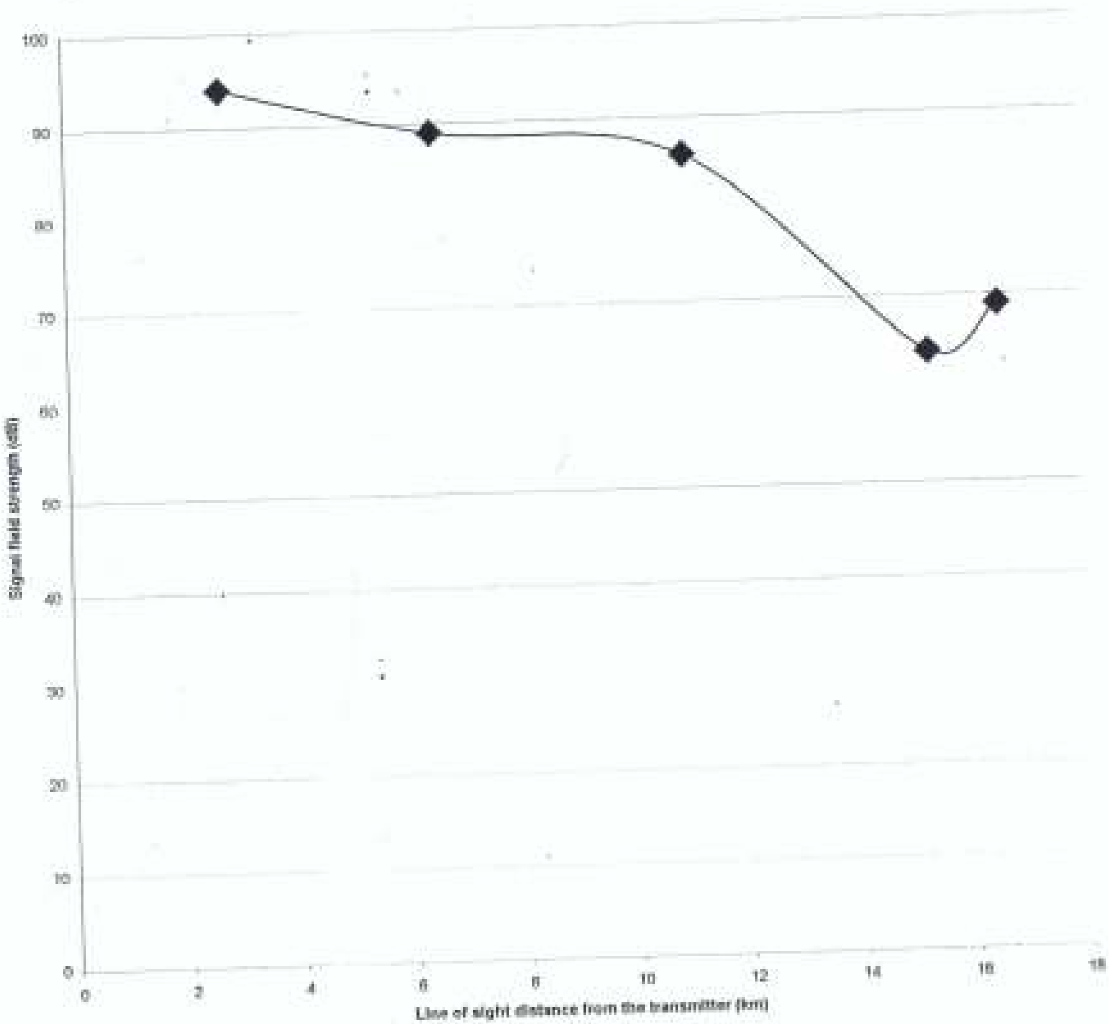


Fig. 5.5b The graph of the signal field strength measured with respect to line of sight distance from the transmitter.

Table 5.2. Field Strength Signal measured at the main Town of Idanre.

S/N	Identified Towns	Line of sight distance from transmitter (km)	Field strength (dB)	Field strength (mV/m)	Path loss in dB.	Height above sea level (m).	Nature of signal	Nature of terrain
1	Gbekemu	16.75	32.00	0.0398	63	360	Multiple image	Rounded by hill
2	Afribank-Idanre	16.80	34.00	0.050	61	330	Multiple image	"
3	Methodist High school. Idanre	17.00	27.00	0.0224	68	350	Multiple Image	"
4	Ese-Gbeke Idanre	17.50	14.00	0.0050	81	332	Multiple Image	"
5	Oke Idanre	17.85	66.00	1.995	29	364	clear	Clear line of sight
6	Depo St Idanre	18.00	36.00	0.063	59	330	Multiple Image	Rounded by hill.
7	Oja-Ale Idanre	18.25	40.00	0.100	55	349	Multiple Image	"
8	Isalu Idanre	18.95	32.00	0.040	63	330	Multiple Image	"
9	Opa	17.00	29.00	0.028	66	288	Multiple Image	"
10	Odole	17.90	34.00	0.050	61	303	Multiple Image	"

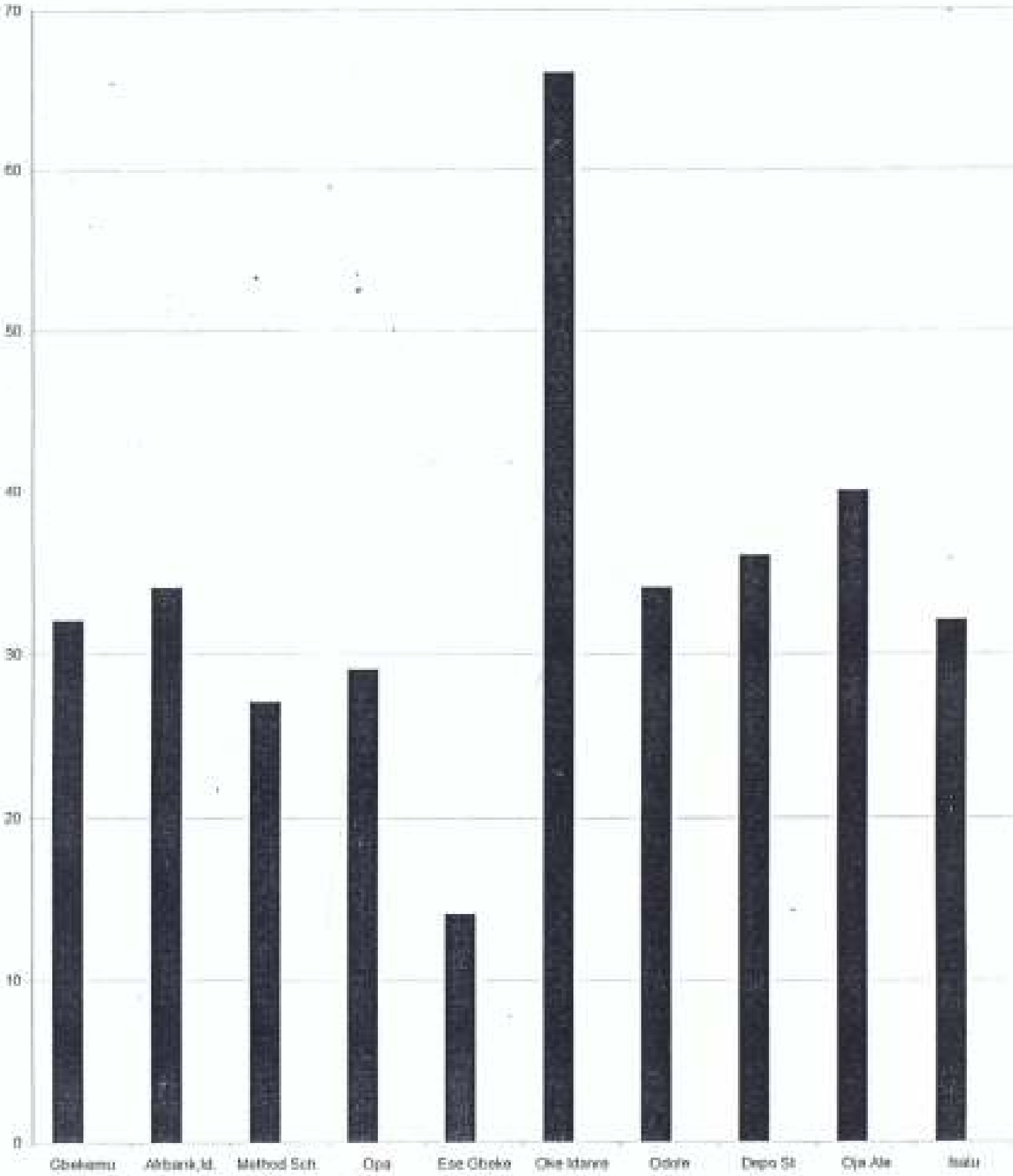


Fig. 5.6a The bar chart showing the signal field strength measured at the main town of Odode Idanre.

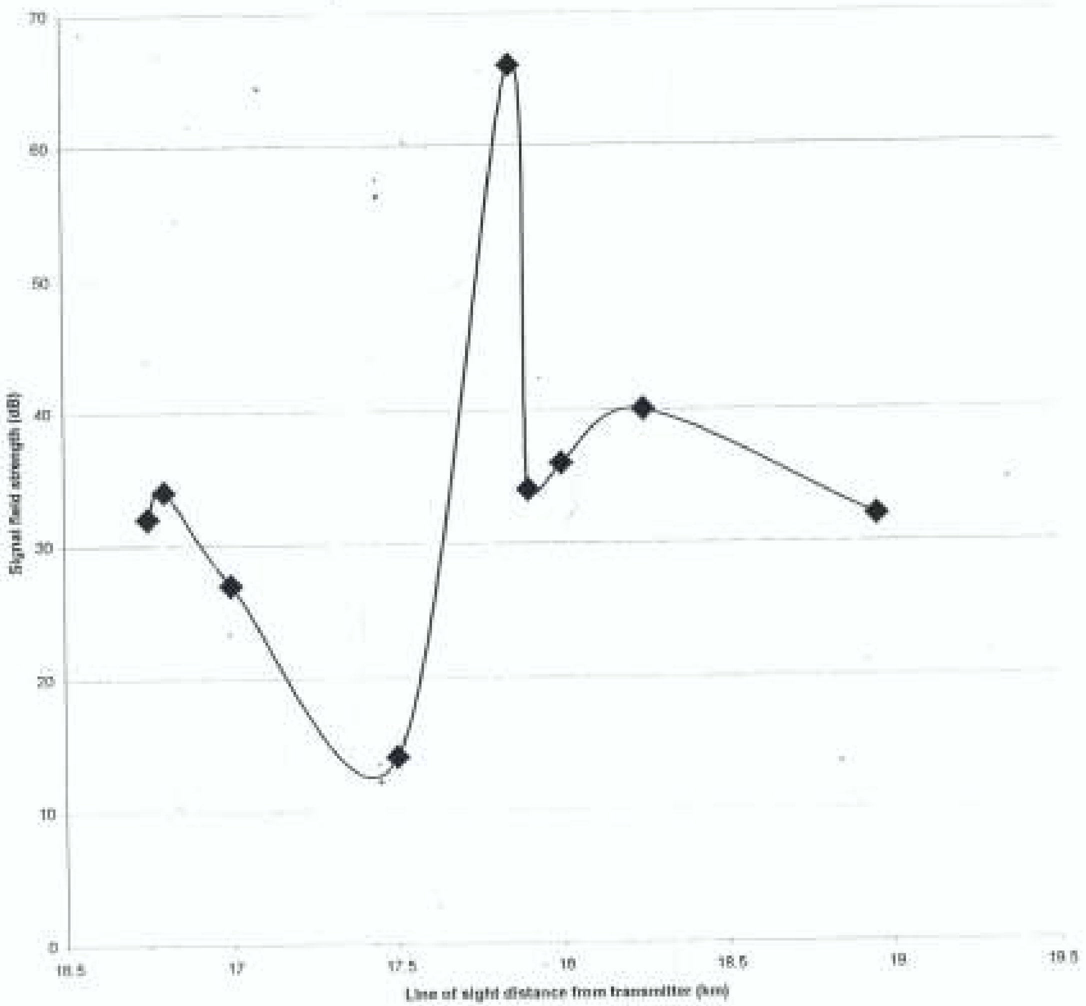


Fig. 5.6b The graph of the signal field strength measured at the main town of Odode-Idanre with respect to line of sight distance from the transmitter.

Table 5.3. Field Strength Signal measured after Idanre.

S/N	Identified Towns	Line of sight distance from transmitter (km)	Field strength (dB)	Field strength (mV/m)	Path loss in dB.	Height above sea level (m).	Nature of signal	Nature of terrain
1	Apefon	19.60	36.00	0.63	59	242	Image	Obstructed by hill
2	Ileromoba	22.00	40.00	0.10	55	288	Image	,,
3	Oniyewu	25.50	44.00	0.158	51	227	Clear	Clear line of sigth
4	Jimgbe	27.50	42.00	0.126	53	227	Clear	,,
5	Odo-Ise	22.75	14.00	0.005	81	364	Image	Rounded by hill
6	Itaja	21.5	12.00	0.0039	83	349	Image	Rounded by hill
7	Igbo-Epo	27.75	12.00	0.0039	83	341	Image	Rounded by hill

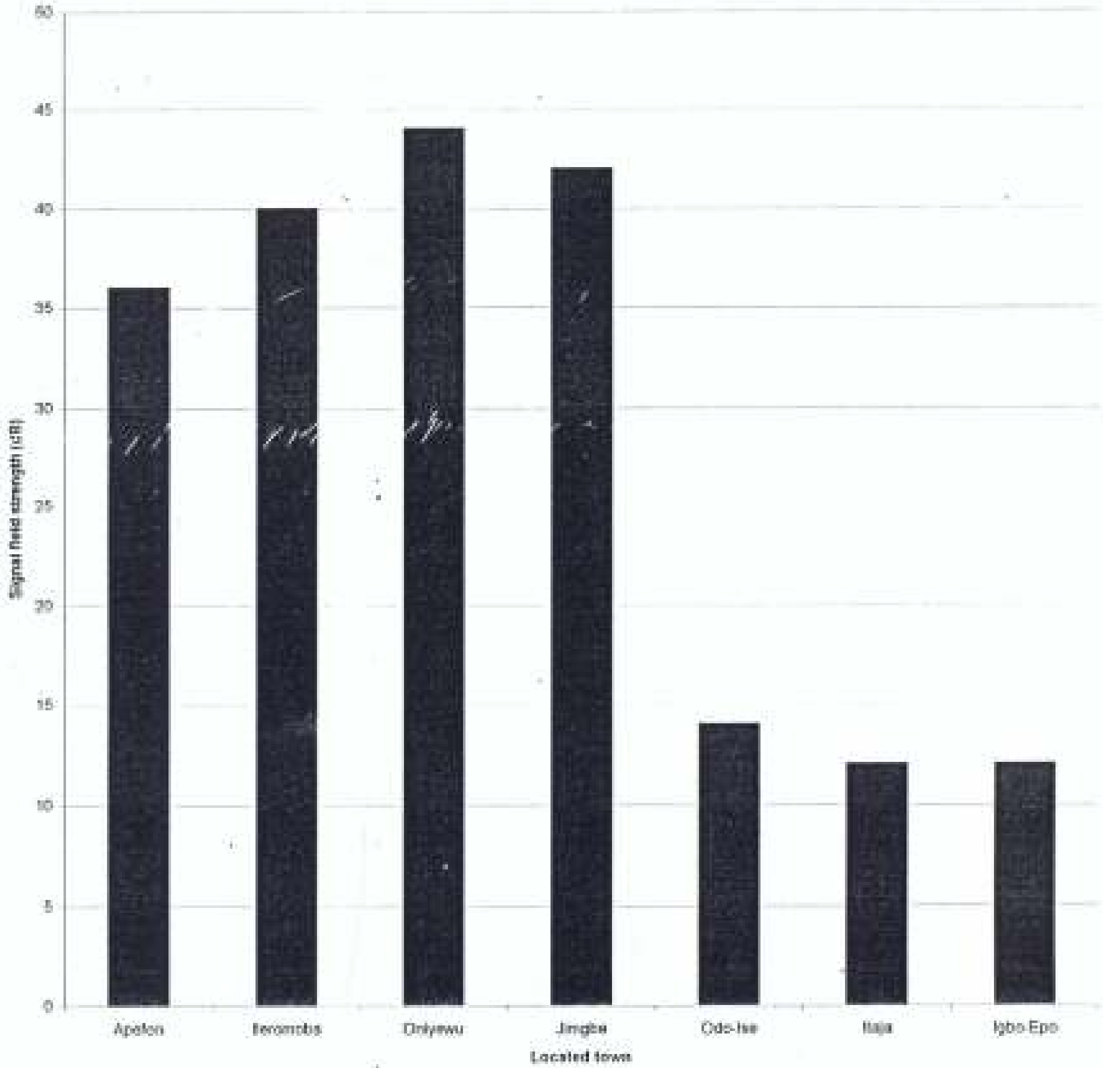


Fig. 5.7a The bar chart showing the signal field strength measured at the specific locations from Apefon to Igbo-Epo, Towns After Odode Idanre.

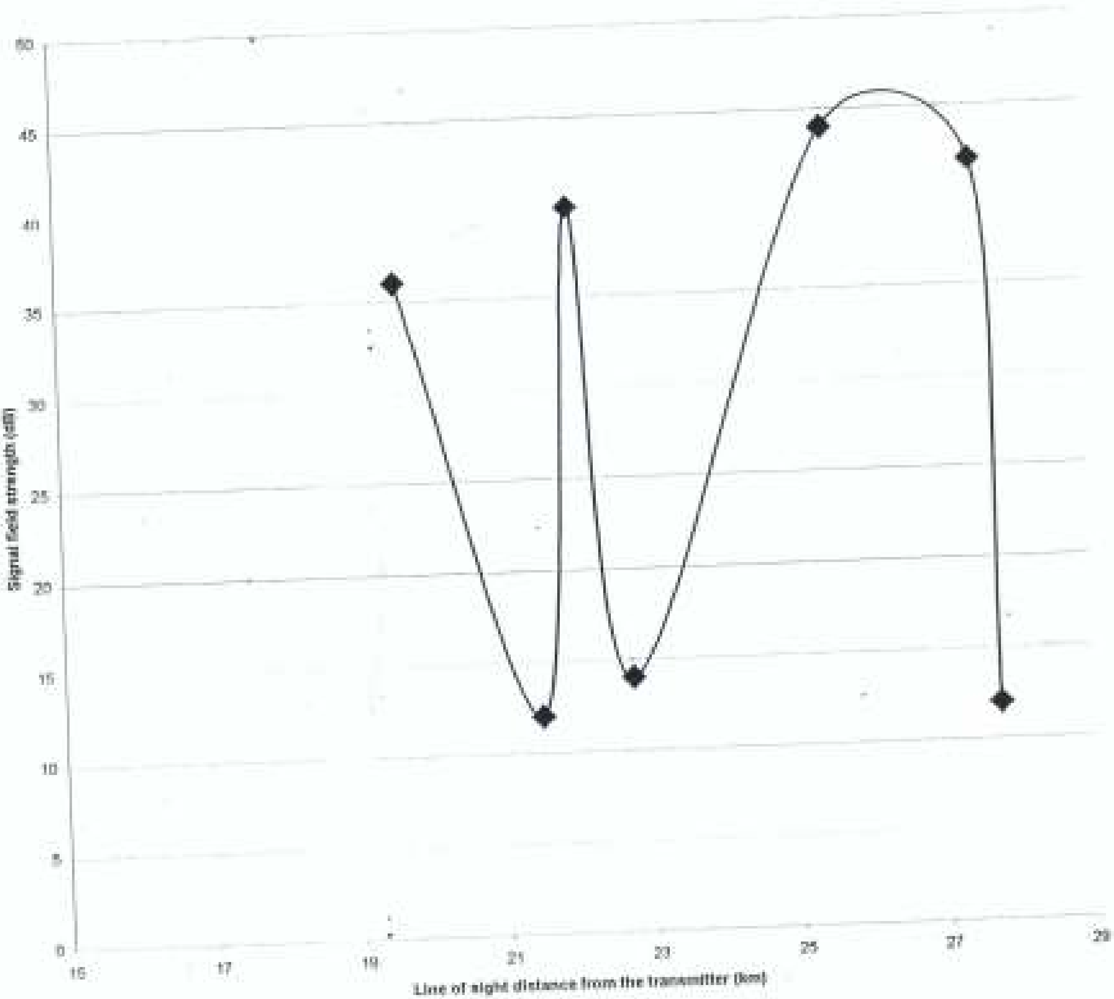


Fig. 5.7b The graph of the signal field strength measured at the towns after Odode-Idanre with respect to line of sight distance from the transmitter.

Table 5.4. Field Strength Signal measured at the forest region of Idanre.

S/N	Identified Towns	Line of sight distance from transmitter (km)	Field strength (dB)	Field strength (mV/m)	Path loss in dB.	Height above sea level (m).	Nature of signal	Nature of terrain
1	Akolo	17.50	44.00	0.158	51	273	Clear	Obstructed by Thick Forest
2	Ayo	19.00	38.00	0.079	57	258	Clear	Obstructed by Thick Forest
3	Apomu	18.50	44.00	0.158	51	242	Clear	Obstructed by Thick Forest
4	Obamotula	24.00	39.00	0.089	56	318	Clear	Obstructed by Thick Forest
5	Aiyefemi	26.50	34.00	0.050	61	227	Clear	Obstructed by forest
6	Onipepeye	27.75	29.00	0.028	66	212	Image	Obstructed by forest
7	Owena	20.00	59.00	0.891	36	239	Clear	Clear line of sight
8	Eripose	21.50	27.00	0.022	68	258	Image	Obstructed by forest

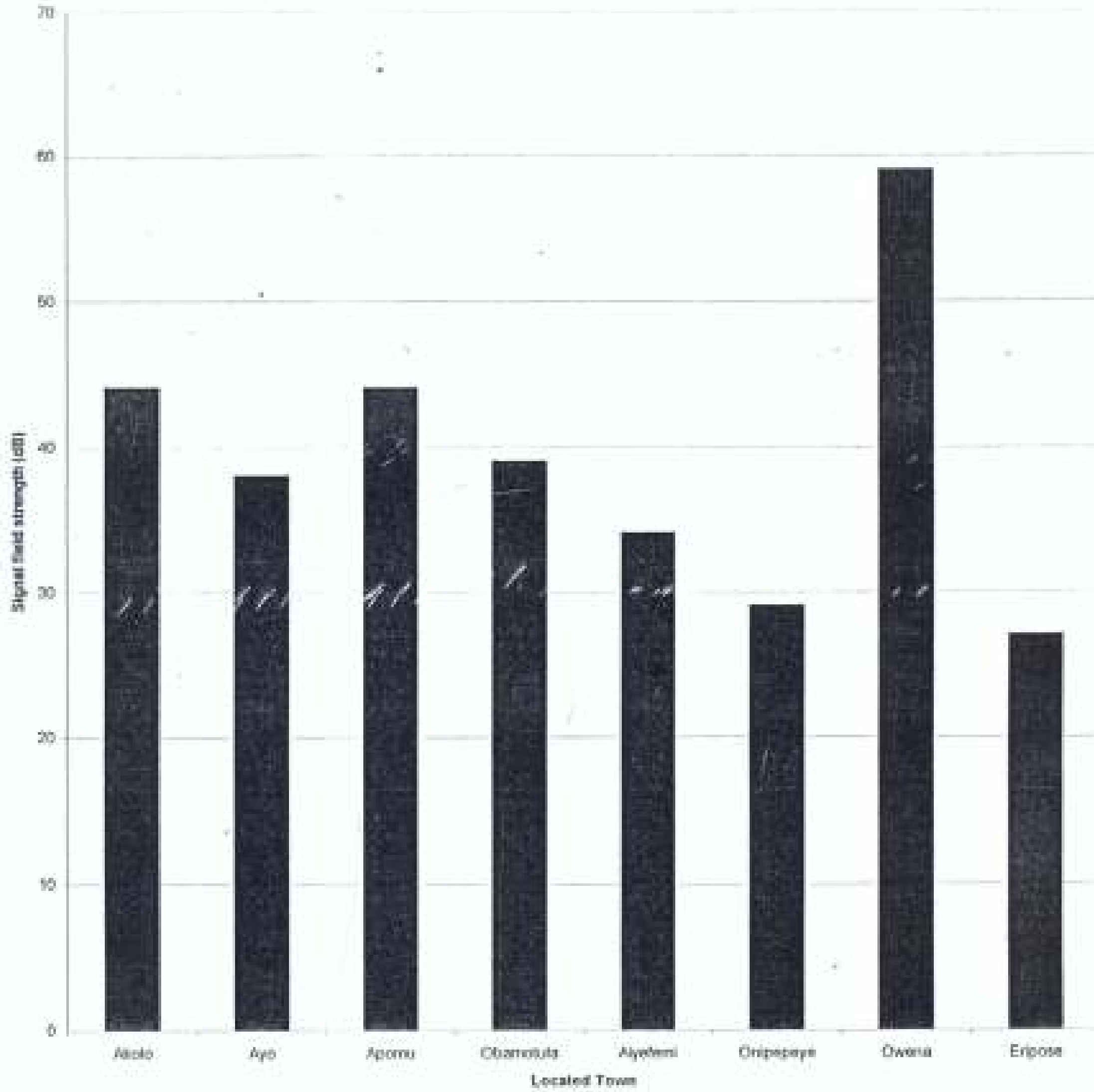


Fig. 5.8a The bar chart showing the signal field strength measured at the specific locations in the forest region of Idanre, from Akolo to Eripose.

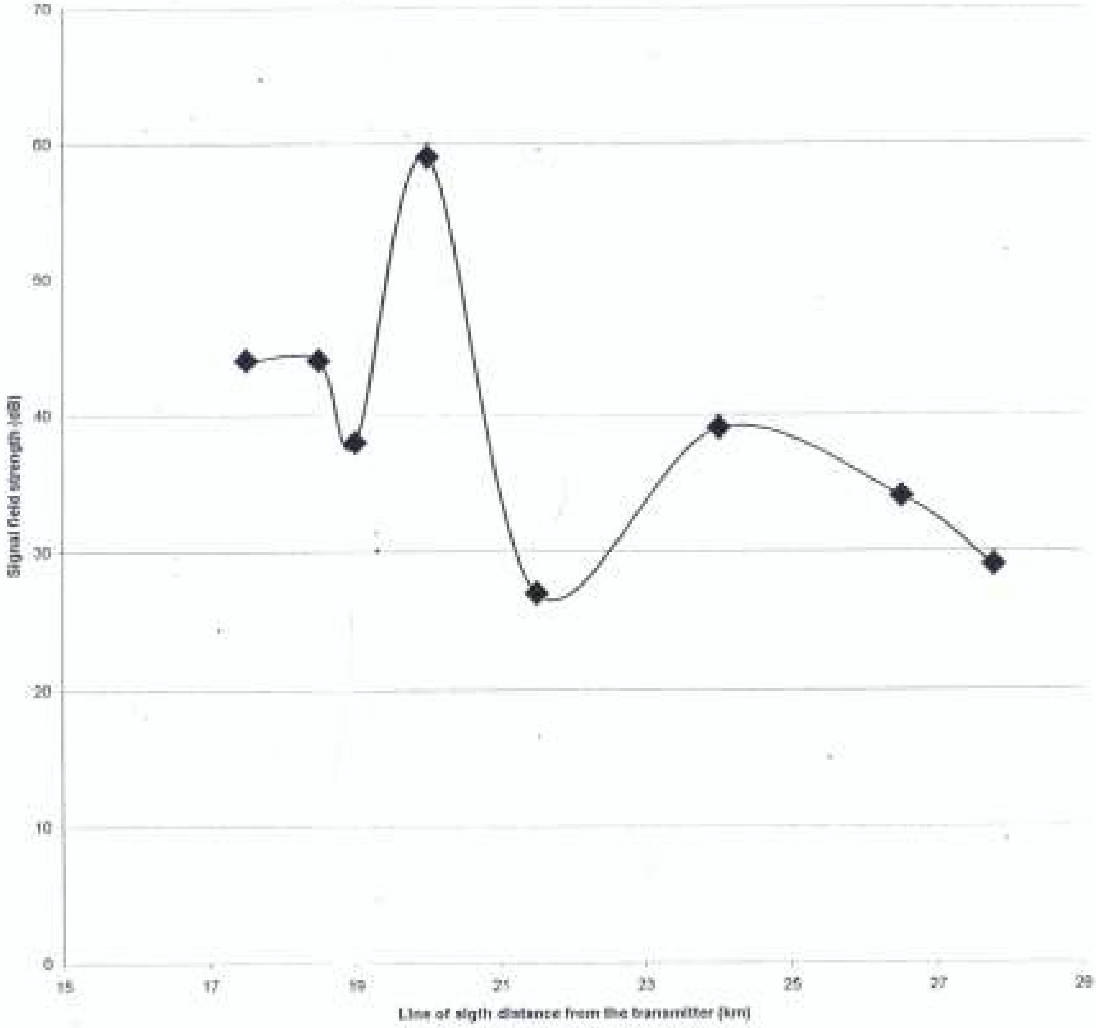


Fig. 5.8b The graph of the signal field strength measured at the towns in the forest region of Idanre with respect to line of sight distance from the transmitter.

5.3 ANALYSIS OF THE REULTS.

The waves which radiate away from the TV station's transmitting antennas travel most easily in dry air, and in paths that are very close to a straight line. Even in dry air they do gradually become weaker with distance, because of the way they are steadily spreading out as they radiate away. But providing there's a reasonably clear line of sight between the receiving antenna and the transmitter tower, and the receiver is not more than 30 km from the transmitter, there should still likely to be strong enough for good reception in most conditions with high gain outdoor antenna.

At these frequencies, though, radio waves do become much weaker passing through solid objects like hills, buildings or a lot of foliage. Those behind a hill or some large buildings, or in a dense forest, the signals that reach the antenna might well be weakened enough to cause poor reception . The mean field strength signal received at each location is given as:

$$P_r = (P_{r0}\alpha_o)L_r\alpha_1\alpha_2.......\alpha_n \quad ....5.1$$

Where all α values are directly applicable and not caused by other factors. L_r is the diffraction lose. α_i (i =1,2,................,n) represents the additional path loss factors due to many other causes. Eqn. 5.1 can be expressed in dB as:

$$P_r = P_{ro} + L_r + \alpha_o + \alpha_1 + ... + \alpha_n \qquad \text{dB} \qquad ....5.2$$

All of the factors in Eqn.5.2 are median values based on the following types of causes:

1 Effects of street orientation.

2 Effects of foliage.

3 Effects of attenuation and reflection of hills.

4 Effects of buildings and structures.

The well known plane wave solution in one dimension is given as:

$$\varphi(x,t) = s(x,t)e^{j\omega_c\left(t-\frac{x}{c}\right)} \quad \text{--- 5.3}$$

Where s(x,t) is the information bearing (or complex envelope) of the wave propagation in the x direction and the carrier frequency in radian/sec. Letting the delay =x/c and making the spatial dependency x implicit we have:

$$\varphi(t,\tau) = \left[s(t-\tau)e^{-j\omega_c\tau}\right]e^{j\omega_c t} \quad \text{---5.4}$$

In a multipath environment, r(t), the complex low-pass representation of the received signal is the contribution of many rays:

$$r(t) = \sum_n \alpha_n(t)s(t-\tau_n(t))e - j\omega_c\tau_n(t) \quad \text{---------------------------------------5.5}$$

Where α_n (t) denotes the time varying complex amplitude of the nth ray. Note that in addition to the time varying amplitude $\alpha_n(t)$, the delay of each path is also a function of time. Equivalently, the RF equivalent counterparts of r(t) and s(t) denoted by S(t) and R(t) are:

$$S(t) = \mathrm{Re}\left\{s(t)e^{j\omega_c t}\right\}$$

$$R(t) = \Re\left\{\sum_n (t)S(t-\tau_n(t))e^{j\omega_c(t-\tau_n(t))}\right\} \quad \text{---------------------------------------5.6}$$

The real problem of this reflection of signals is the arrival of the reflected and direct signals at the receiver at different times as in the Fig. 5.9. Since radio waves travel in air at virtually the same speed, c, as light of 300,000 km/s. So the receiving antenna at a distance R km from the transmitting station receives its signals in R/c seconds. Not that this tiny delay is aware of but this infinite speed does become important when reflected signals from the same station can also reach the antenna, say by reflection from a hill.

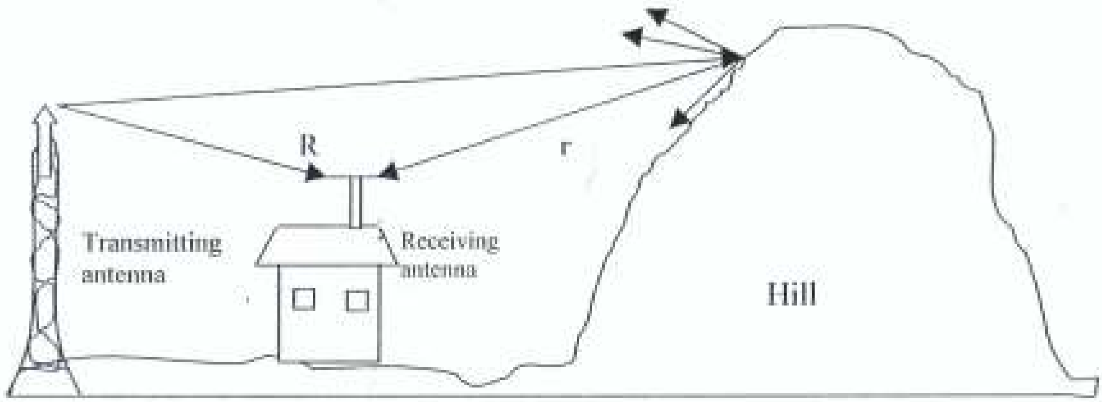


Fig. 5.9 The reception of direct and reflected signals that causes ghosting.

The reflected signals also travel at the same speed, but clearly they're traveling along a longer path to get to the antenna. This means that they'll take slightly longer time to get there, arriving just after the signals which arrives via the direct path (which is the clearly the shorter path).

As a result, the set receives a mixture of two distinct version of the station's signal, one always arriving r/c seconds after the other. So instead of getting just one picture on the screen, two or multiple pictures is obtained depending on the number of reflected rays trapped by the antenna, the main one (from the direct path) and weaker one(s) (from the reflected path). The weaker one shifted to the right, because of the way the TV set scan the picture lines from left to right. The second picture was usually less distinct and more weakly coloured, because it is from weaker signal. Although, the extra ghost images were fainter and more weakly coloured, they were quite distracting and seriously degrade the clarity of the main picture. This is why they are regarded as a reception problem as in photograph 1.

Photograph 1: An example of ghosting from the received signal.

Where it is difficult to track down the exact source of the reflected signal that is producing a ghost, an important point could be work out from a careful inspection of the TV screen; how much further the reflected signal is traveling compared with the direct path signal. This is done by carefully measuring how far the ghost image is to the right of the main image, as a proportion of total picture width.

Therefore by measuring the separation between the main and the ghost image, dividing this by the total picture width and then multiplying this by time, τ , given as :

$$\tau = \frac{1}{\text{Frame transmitted/ sec} \times \text{line per screen frame.}}$$

For PAL TV system:

Frame transmitted per sec. = 25

Line per frame = 625

Hence,

$$\tau = \frac{1}{25 X 625}$$

$$= 64\ \mu s$$

This scan time corresponds to a distance of 19.2 km, i.e. scan time X speed of radio waves in air in km/ µs, (=0.3 km/ µs).

For NTSC TV system:

Frame transmitted per sec. = 30

Line per frame = 525

Hence,

$$\tau = \frac{1}{25X625}$$

$$=63.5 \ \mu s$$

This is the time used to scan the line of the TV screen which could be seen from above that it depends on the TV system. This gives the time in microseconds that reflected signal is being delayed compared with the main signal. Since the speed of the radio waves in air is known, then the extra path length that results in this time delay could be obtained. This extra path length in kilometer in given as:

$$P_X = T_d \ X \ 0.3$$

Where P_X is the extra path length in km and T_d is the reflected signal delay in μs worked out from the ghost image separation. The extra path length could also be calculated if the distance between the main picture and the ghost image and the screen width are known using this relation:

$$P_X = \frac{D_g}{W_s} \ X \ 19.2 \ \text{km.}$$

Where P_X = Extra path length in km

D_g = Distance between the main and ghost images

W_s = The screen width.

The direction that the reflected signal is coming is also important to determine what to be done in other to reduce the impact of the reflected signal using high gain directional antenna with narrow beam width.

Hence,

- In analyzing the effect of terrain on reception, the following determinants are taken into consideration :
    1. The amount by which the direct ray clears terrain prominences or is blocked by them.
    2. The position of terrain prominences or obstacles along the path.
    3. The strong influence of the degree of roundness of these terrain features.
    4. The apparent earth flattening due to atmospheric refraction.

Even in line-of-sight conditions when all terrain prominences lie below the direct ray, some may come close enough to weaken the received field. This weakening effect is evaluated in terms of the degree to which prominence penetrates certain geometrically defined zones, called Fresnel zones, around the direct ray. Determinant (2), position o the prominence or obstacle along the path, is important because the foot-ball shaped Fresnel zones are fatter and thus more deeply penetrated in the middle than at the transmitter and receiver ends.

CHARPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1 CONCLUSION :

From the results and analysis of chapter five, it could be concluded that trees, foliage and high hills on a transmission path have much effect on the reception of television signals. Variations in the contour and roughness of the terrain, including any scatters that are present, cause changes in reception as the result of specula reflection, diffuse reflection, and diffraction. This also shows that television signals reach the TV receiver by a longer path after reflection on the hills.

6.1 RECOMMENDATION.

IN THE LOCATION OF THE AFFECTED VIEWERS.

In giving suggestions to the affected areas, the economic viability should also be put into consideration so that the people concern could afford this and the problem to be solved. In view of this, the suggestions are categorise into two categories:

Category A: This could be afforded by individual because of its cost less implication.

1. Replace receiving aerials for affected households.

   Receiving aerials with superior performance to the discrimination template shown in Fig. 2.3 Are available. These can produce a narrower receiving beam-width; so they will discriminate better against unwanted signals arriving from other directions and also a higher gain (so the receiver can be made to work in areas of lower signal strength). Log-periodic aerials, which have the ability to reject signals arriving from the sides and rear of the transmission path, are also known to be effective in combating reflections. Clearly, these measures will not work if the reflected signal is coming from the same direction as transmitter.

2. Re-tuning television receivers at affected households.

   If the affected area is served adequately by transmissions from an alternative transmitter, receivers can simply be re-tuned to the unaffected service. This will also require changing the direction in which the receiving aerials are pointing, and maybe even replacement of the receiving aerial as most aerials will not cover the entire range of broadcast frequencies.

3. An antenna be erected at point A in Fig. 2.3a to serve as a community antenna so that it could serve many houses.

Category B: This could only be afforded by the government because of the cost implication and what it entails to site a repeater station.

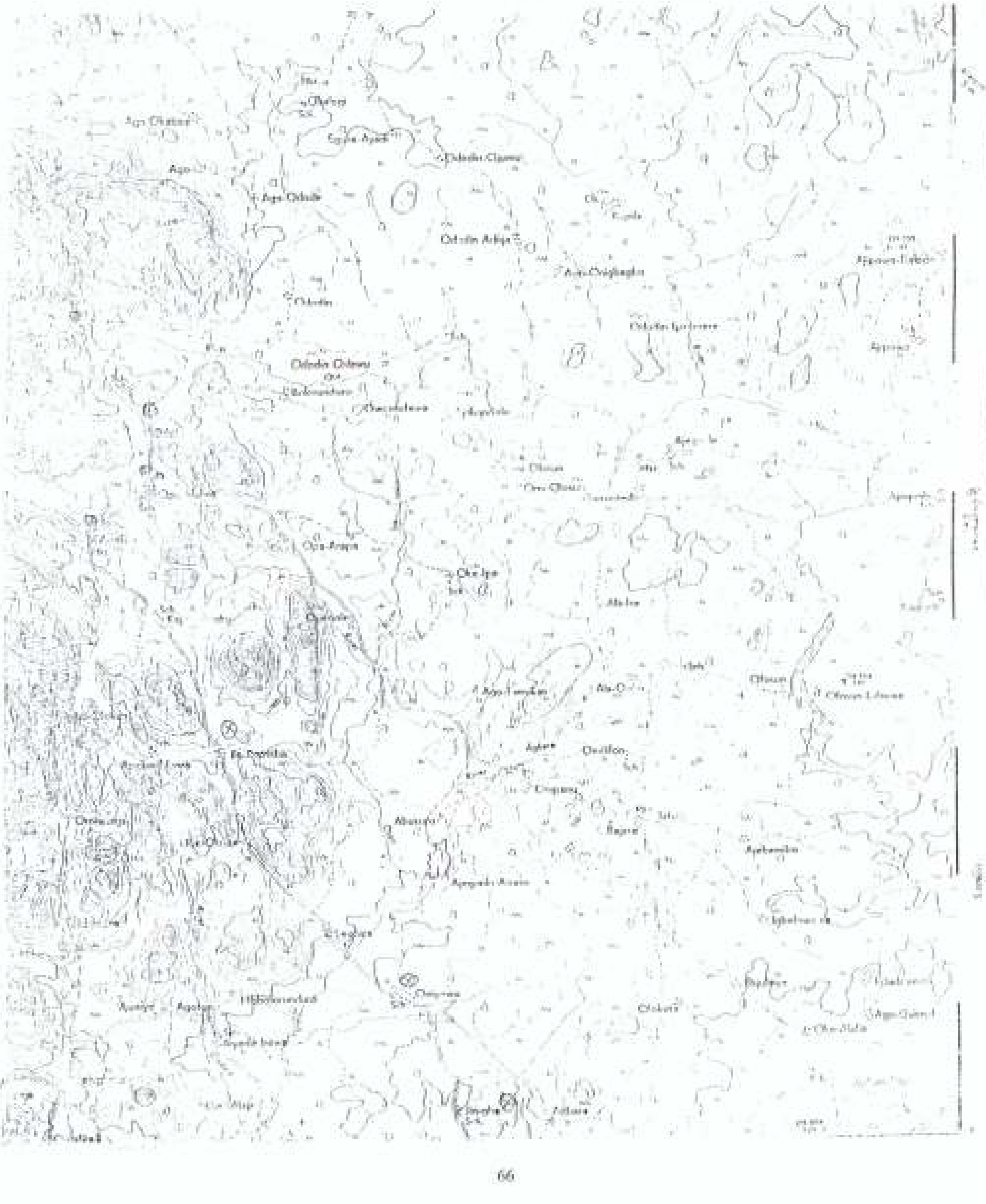
1 A small repeater station be sighted at point B (a little distance from the shadow region) in Fig. 2.3a so that it could direct its own transmitted signal towards the shadow zone(but at different frequency) for the people living in the shadow region to receive better signal.

2 A small repeater station be sighted at point A in Fig. 2.3a to change the polarization of the incoming signal (from horizontal polarization to vertical polarization) so that people in the valley could receive a clear signal.

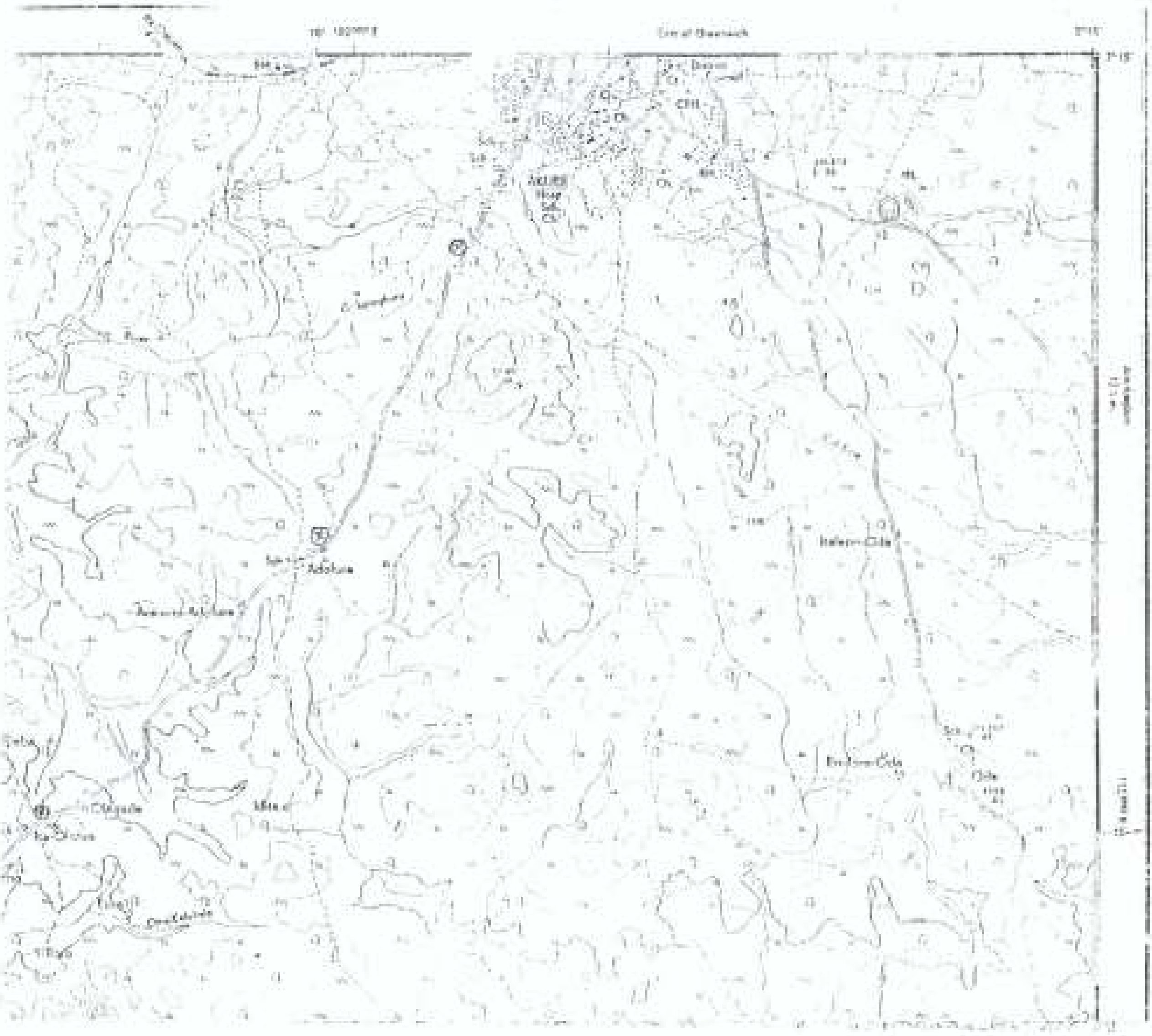
As a ghost image corresponds to a second version of the signal from the TV station, reflected from a large object and this arriving via a longer path, this means that often its also arriving form a different direction. So with a large gain, very directional antenna it is often possible to swing the antenna around a little to the left or right so that it still receives the direct path signal at good strength, but picks up very little of the reflected path signal that was responsible for the ghost.

In really stubborn cases where a single very directional antenna can't reject the reflected path signal enough by itself to lay the ghost, it is possible to use a second very directional antenna to receive the reflected path signal by itself, and then add this antenna's signal to that from the main antenna with the connections reversed so the reflected path is cancelled out.

Appendix I: Contour Map of Akure south west showing the towns after Idanre

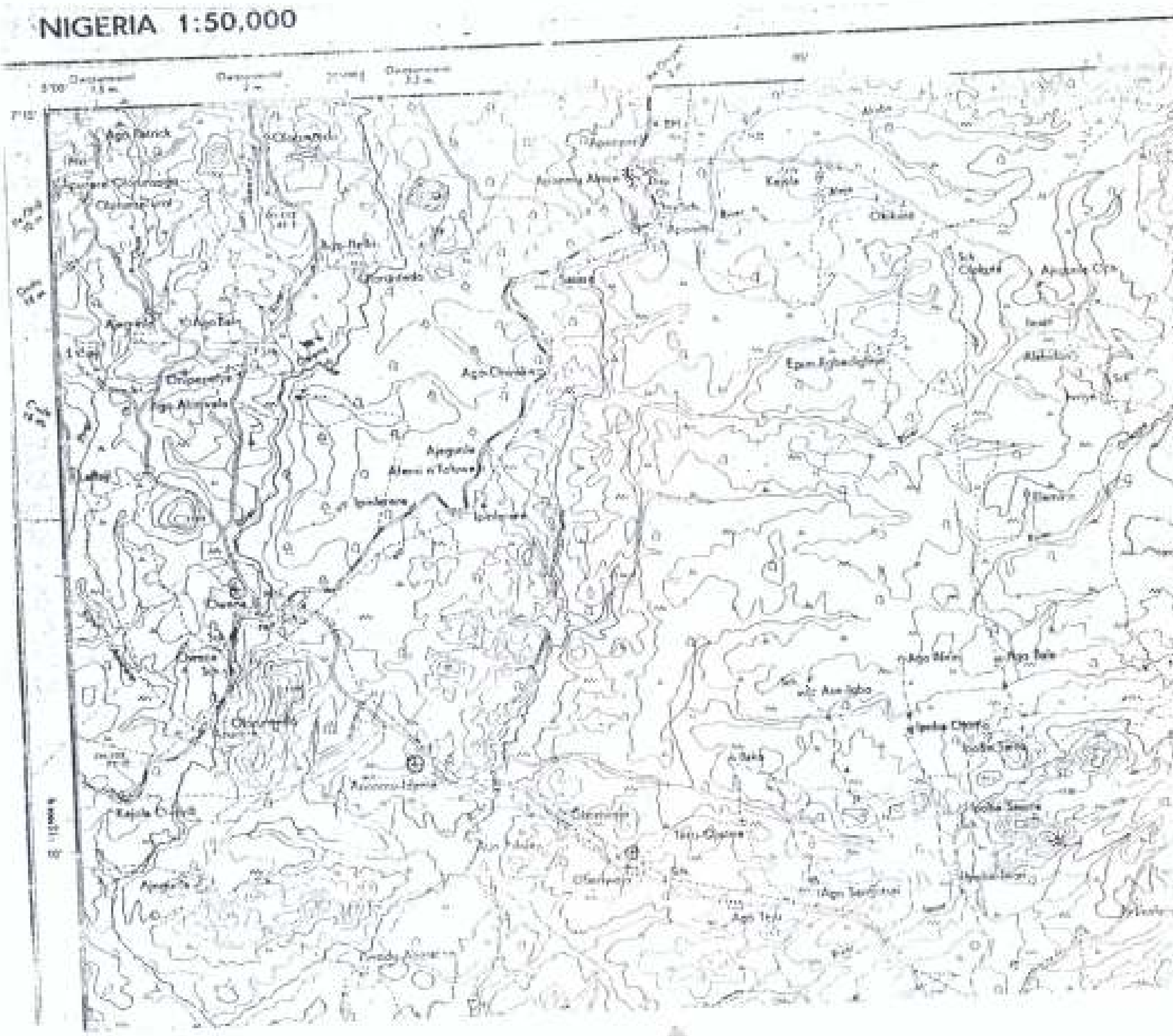


Appendix III: Contour Map of Akure south west showing the towns before Idanre.



Appendix IV: Contour Map of Akure south west showing the main town of Idanre.

Appendix II: Contour Map of Akure south west showing the towns behind the Idanre hills.



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