# Effects of Hilly Terrain on UHF Band Radio Frequency Propagation

**Famoriji John Oluwole**[1], **Olasoji Yekeen Olajide**[2]

[1]Electrical and Electronics Engineering Department, P. M. B. 704, Federal University of Technology, Akure, Nigeria
*famorijijohn@yahoo.co.uk*

[2]Electrical and Electronics Engineering Department, P. M. B. 704, Federal University of Technology, Akure, Nigeria
*yoolasoji@futa.edu.ng*

**Abstract:** ***All wireless communication (wireless network) links point-to-point and point-to-multi-point stations through the transmission of an electromagnetic wave which is received at the other end of the receiving station. Factors such as buildings, trees, hills, rain e.t.c cause signal degradation during wireless transmission. Attenuation caused by hills informed the basis for this research work. Measurement results of signal strength in UHF band obtained where there is and where there is no high hill in Idanre Town of Ondo State Nigeria were compared. Consequently, field strength decreases rapidly as the point of observation moves deeper into the shadow zone.***

**Keywords:** Wireless network, Hill, Measurements, Shadow zone, Idanre

## 1. Introduction

Since the proliferation of wireless devices in the 1990s, the study of radio frequency (RF) propagation in the hilly or mountainous environment has received much attention. With the increased demand for products and services incorporating wireless technology, the need for research into the behavior of RF propagation in the urban environment has come to the forefront (Tanenbaum, 2003) [1]. Ostlin et. al. (2005) [2] reported that when a mobile user moves over large distances the attenuation of propagating radio waves is affected by the antenna separation distance and large objects, such as hills, buildings and vegetation. Smaller objects in the radio channel, such as trees, uneven walls, cars and lamp posts, induce more rapid signal variations in the propagating radio waves.

Therefore, system engineers need accurate understanding of the channel to allow for reliable and robust design of cellular mobile radio networks.

## 2. Propagation Mechanisms

Propagation mechanisms may generally be attributed to reflection, diffraction and scattering Ostlin et. al. (2003) [3]. Free space conditions are almost never at hand and the effect of the atmosphere can usually be ignored for the very high frequency (VHF) and the ultra high frequency (UHF) bands.

### 2.1 Reflection

Reflection occurs when a propagating electromagnetic radio wave encounters an object, which has large dimensions compared to the wave length. In practice, radio waves travel through air and encounter objects and surfaces, such as buildings, other large man-made or natural occurring objects, earth and water. Due to different impedances between the air and the encountered object, a part of the energy is reflected whilst the remaining part is refracted into the other medium Parson, (2000) [4]. Typically, the encountered object is not a perfect conductor and hence signal power will be lost in the reflection Ostlin et. al. (2003) [3]. The proportion of energy reflected from and refracted into the encountered object is dependent on the electric properties of the media, the electromagnetic wave's reflection and incident angles (which are the same) and the properties of the electromagnetic wave.

### 2.2 Diffraction

The term diffraction is used to describe how radio waves bend over or around the edge of an obstruction. Diffraction occurs when the obstructing object is large compared to the wave length of the radio wave. Often Huygens–Fresnel principle Stein (1987) and Hagan and. Mehaj (1994) [5, 6], which may be extracted Rojas (1996) [7] from Maxwell's equations. Hagan and Demuth (1999) [8] is used to give an insight to the diffraction phenomenon.

### 2.3 Scattering

Scattering is related to reflection and is sometimes referred to as diffuse reflection. For example, when a reflecting planar surface becomes more irregular, scattering will occur with a higher probability. When scattering occurs, the energy of the radio wave is distributed in all directions. Typically, scattering objects consist of trees, uneven walls, cars, lamp posts and other small objects.

## 3. Geography of Idanre (Study Area)

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 Iikale, also of Ondo state. Akure however, is Idanre's neighboring town 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 (177.8cm) though with slight variations from year to year, thick clouds envelope 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 (the prominent hill of Idanre) becomes almost invisible as haze perpetually engulfs its topmost. Plate 3.3 shows the map of Ondo State showing Idanre and Akure south local government. Nonetheless, between January and July, the temperature averages 78$^0$F (25.56$^0$C) and 83$^0$F (28.33$^0$C) 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 are distinguishable through their individuality and often about 45m in height; next to these are trees between 23m and 3.6m tall, whose branches 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. These trees combine with those in others to form impenetrable forest.

## 4. Methodology

Series of these measurements were carried out using the appropriate field strength meter. Signal field strength measurements were carried out in two regions: where there is and where there is no high hill using a professional TV signal field strength meter type UNAOHM model EP742A. A Yagi array receiving antennae covering both VHF and UHF frequency bands was used for measurements. This was mounted on support about eight meters above the ground to prevent grounding adverse effect on the reception, and positioned before the hills. It was also positioned after the hills to see the effect it has on the broadcast signal. The Yagi array was coupled through a 50-ohm feeder to a UNAOHM TV strength meter type EP742A, designed for monitoring and measuring TV broadcast signals (vision and audio), in the VHF/UHF Bands I, III, IV and V. GPS (Global Positioning Satellite (GERMIN model)) was used to determine line of sight (LOS) distance between the transmitter and the observation points. Equation 1 as obtained from Rappaport 2002 was used to determine theoretical value.

## 5. Results and Discussion

The results of measurements taken before and after the hill are shown graphically in Figure 1 and 2 respectively as plot of field strength against line of sight distance.

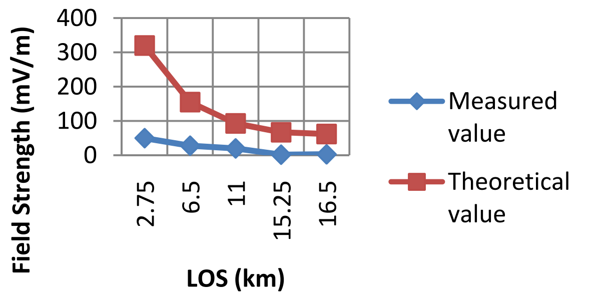


**Figure 1.** Graph showing the relationships between the measurements obtained and the theoretical measurements in the area where there is no high hill.

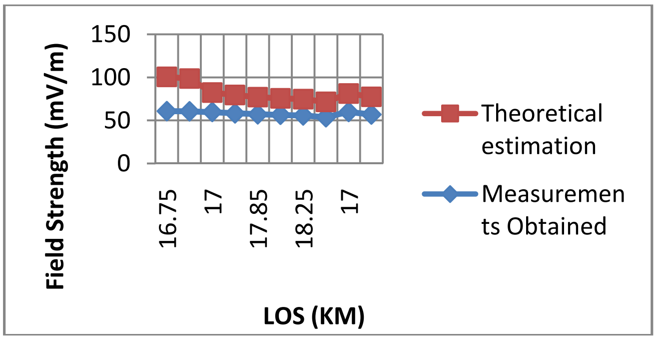


**Figure 2.** Graph showing the relationships between the Measurements Obtained and the Theoretical Measurements in Hilly Area.

Figure 1 and 2 show the relationships between the measurements obtained and the theoretical estimations for the areas where there is no high obstruction and the areas with obstruction respectively. With the disparity shown between these graphs, it could be deduced that the propagation here suffered attenuation caused by atmospheric refraction; the ionosphere and the neutral atmosphere induce propagation delays. In the neutral atmosphere, delays are induced by refractivity of gases, hydrometeors, and other particulates, depending on their permittivity and concentration, and forward scattering from hydrometeors and other particulates. Changes in temperature, moisture, and pressure in the atmospheric column cause a change in atmospheric density, which in turn causes variations in the intensity of waves in both the vertical and horizontal. Reflection and diffraction caused by obstruction and the effect of tree density with foliages in that area. 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 the area (forested environment) most especially in Ogburugburu (LOS 2.75km) of Figure 1 that is more forested than others; a major reason for its wider disparity. Apart from the above, Figure 2 also shows that field strength decreases rapidly as the point of observation moves deeper into the shadow zone.

## 6. Conclusion

This research work investigated the effects of hilly environment on radio wave propagation. Measurements were taken in area where there is high hill and area where there is no high hill in Idanre. The results of measurement were validated with theoretical measurement; disparity shows that the presence of vegetation produces a constant loss independent of distance between communication terminals that are spaced 1 km or more apart. The density of foliage and the heights of trees that are not uniformly distributed in a forested environment caused variation in the signal reception at different points. Also field strength decreases rapidly as the point of observation moves deeper into the shadow zone.

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## Author Profile

**Famoriji John** received the B. Tech and M. Eng. Degrees in Electrical and Electronics Engineering from Ladoke Akintola University of Technology in 2009 and Federal University of Technology respectively. Research interest is channel characterization and sounder design.

**Olasoji Yekeen** received the B. Sc, M. Sc and Ph. D in Electrical and Electronics Engineering from reputable universities. He’s currently a senior lecturer in Electrical and Electronics Engineering of Federal University of Technology. Research interest is wireless communication engineering.