Wireless Radio Signal Drop due to Foliage in Illuba Bore Zone, Ethiopia

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Abstract: **The exponential growth in energy utilization & consumption in cellular network by the user devices and by telecom equipment has imposed critical problemsbecause of adaptation of high range frequency in available spectrum (Ultra High Frequency-UHF) by government and technology.The other reason for more power consumption is extensive applications of mobile data services to video streaming, surveillance, internet surfing and healthcare monitoring.Other important causes of energy consumption which has been recognized are power-hungry processors, poor design of power amplifiers etc. Presence of different species of foliage in hilly area increases signal attenuation, consequently in order to maintain the threshold value of signal, the power is increased. The recent researches predict that the data traffic is being increased by several-fold every year. Under such predictions, energy expenditure at its control is a major challenging task for telecom companies and for research communities. This paper studies the actual signal intensity drop because of irregular nature of terrestrial pattern and foliage in Illuba Bore zone, from theoretical perspective as well as practical point of view.**

Key-words: **Foliage, Antenna Gain, Path Loss, EIRP, Polarization.**

I. INTRODUCTION

The presence of high densities of long trees with different species acts as reflectors and scatters for electromagnetic (EM) wave. Consequently, it increases the path loss in between transmitter and receiver. The exact estimation of the attenuation and degradation of ultra-high frequency signal(UHF) due to trees are rather complex because there are so many variables like height of tree, shape, density, season and humidity are involved in cause of attenuation. In urban or sub urban areas, where there is a small concentration of trees, the effect is negligible.

1.1 pecific Objective: Specific objective of this paper is concerned with the determination of, actual value of signal drop due to foliage, present over the hilly terrain of the illuba Bore zone in Oromia region of Ethiopia.

1.2 Types of Forest & its Consequences in Illuba Bore Zone: Geographically, the entire illuba Bore zone is located on the oldest rock of Precambrian basement [1, 2] and covered by humid broadleaved forest and low land evergreen forest [1, 3]. Major portion of this zone has series of steep valleys & range of hilly terrain. Notified forest contains the species of Aningena *adolffifriederici* and *Albiziagummiferatrees, which* are 10-30 meters in height [3]. Hence, it works as signal obstructions & absorbing bodies for radio signal. So, effect of foliage & hilly terrain on signal intensity drop can't be neglected. The suggested formulae [4] for signal loss (L) in dB/m because of foliage are

$$L = 1637\sigma + \frac{\exp(-90/f)\log(1+f/10)}{2.99} \tag{1}$$

(In Vertical Polarization)

$$L = 1637\sigma + \frac{\exp(-210/f)\log(1+f/200)}{2.34} \tag{2}$$

(In Horizontal Polarization)

Where,

σ = Conductivity of foliage. (Siemens/meter).

f = Signal Frequency (Mega Hertz).

Conductivity of evergreen forest has value from $1x10^{-5}$ to $5x10^{-5}$ s/m [4].So, simulated graph for signal loss as a function of frequency in ultra-high frequency (UHF) band at different conductivity shows high signal drop at highfrequency. This can bealso seen in figure -1 and in figure -2, where signal loss per meter (dB/m) is higher for vertical polarized wave in comparison to horizontal polarized wave.

1.3 Field Observation in Illuba Bore Zone: For the determination of path loss, frequency band of 15000 MHz has been chosen along with the other parameters value as tabulated in table-2.All data is collected from different telecom sites, which are located in the Mettu town and its surrounding. Measurements have been taken with Ericsson kits. Site number and its corresponding name are listed in table-1.

II. USED FORMULA AND CALCULATION

$EIRP=P_T +G_T-L_T$ (3)

Where, EIRP=Effective Isotropic Radiated Power (dBw)

P_T = Transmitted power (Tx) in dB

G_T= Transmitter Antenna Gain in dBi

L_T = Feeder Loss in dB (assumed zero)

Receive+d Power (dB) =EIRP+ G_R –Path Loss (4)

Where, G_R =Receiver Antenna Gain in dBi.

So, practical value of Path Loss (L) by equation 3 & 4 is tabled in table-3.

III. CALCULATION OF PATH LOSS (L) BY FREE SPACE PATH LOSS MODEL

As per Friis-Free Space Transmission model, the general formula for path loss (in dB) can be written as

$$L = -10 \log G_T - 10 \log G_R - 20 \log \lambda + 20 \log d + 21.98 \quad (5)$$

Where,

λ=Wave length of propagated signal,

d= Separation between transmitter and receiver.

So, according to available data as in table-2, equation-5 can be modeled as equation-6 having frequency in MHz and distance in km.

$$L = 20 \log f + 20 \log d + 1.17 \text{ dB} \quad (6)$$

$$L = 20 \log d + 84.70 \text{ dB} \quad (\text{At } f = 15000 \text{ MHz}) \quad (7)$$

Now, Equation-7 is the resultant equation for path loss in free space as per used data and table-4 shows the value of path loss for recorded sites.

3.1 Calculation of path loss due to foliage in hilly terrain environment:

Various models with different cases has been proposed to calculate the path loss in hilly and rocky areas such as Knife –edge diffraction loss model, Bullington'smodel,Epstein-peterson model and Deygout's model. All aforesaid models are based upon some ideal presumptions like single or two-obstruction case. But in Illuba Bore zone, a continuous obstruction is found due to presence of tall tress situated over the hills. So, these models cannot predict the actually path loss in this region.

So, suitable method for path loss calculation due to foliage in hilly terrain environment (HTE) is only, difference of practically observed path loss value and free space path loss value. Final value of path loss in our case is shown in table-5. Therefore, it can be focused that attenuation caused by foliage at frequency of 15 GHz in theUpland Rain Forest and Lowland Green Forest with leaves is 7 to 27 dB per kilometer extra in comparison to free space loss in Illuba Bore zone.

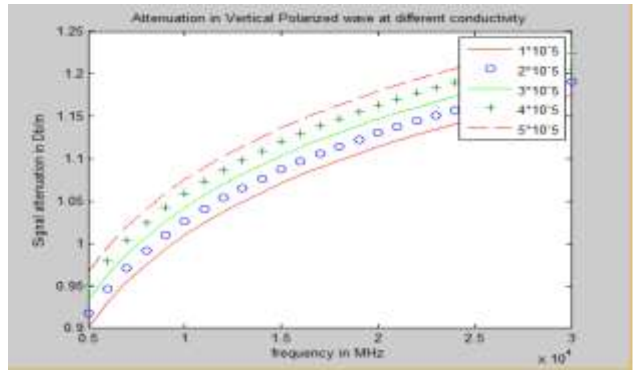

Figure-1

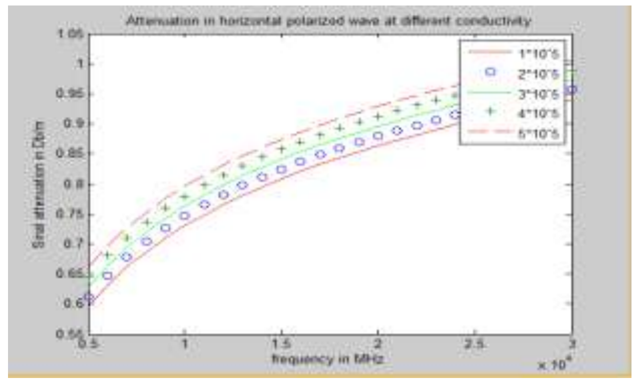

Figure-2

Table-1(Ethio- Telecom Sites for Observation in Jimma Circle)

S.NO	Site Name	Observed Range
1	AabdiBori (Mettu)	1.7 km
2	Shore River (Mettu)	1.2 km
3	Hotel Illu Green (Mettu)	2 km
4	CBE,BranchMettu	2 km
5	Mettu Poly-Technique	5 km

IV. RESULTS, DISCUSSION AND PROBLEM'S SOLUTION

Fig. 1 and fig.2 shows comparison between path loss variations obtained due to foliage, based on different value of forest (evergreen) conductivity. This reveals that with increase of operating frequency and forest conductivity, signal attenuation per unit length increases in both case of antenna polarization. Table-5, it summarizes that with equal antenna size, and equal antenna gain, loss can be minimized by using high valued effective isotropic radiated power (EIRP) antennas. Practical observations in case of Illuba Bore zone, it figure out that signal drop varies from 7 to 27 decebel/km

Table-2(Necessary Data for Path Loss Calculation from different Sites)

Site-No ⟶	**1**	**2**	**3**	**4**	**5**
Tx Power(dBm)	8	5	9	10	16
Rx Level(dBm)	-39.7	-39.9	-40.5	-39.5	-40.5

Frequency(MHz)	14672	14616	15106.5	15106	14588
Path Distance(km)	1.69	1.2	2.06	2.0	4.49
Polarization	Vertical	Vertical	Vertical	Horizontal	Horizontal
EIRP(dBw)	14.6	11.6	15.6	16.6	22.6
Radio Type(m)	0.6	0.6	0.6	0.6	0.6
Transmitter Ht(m)	25	20	30	13	38
Receiver Ht(m)	25	12	30	16	40
Antenna Gain Tx (dBi)	36.6	36.6	36.6	36.6	36.6
Antenna Gain Rx(dBi)	36.6	36.6	36.6	36.6	36.6

Table-3 (Practical value of Path Loss as per collected data)

Site No →	**1**	**2**	**3**	**4**	**5**
Path Loss(dB)	120.9	117.9	122.7	122.7	129.7
Polarization	Vertical	Vertical	Vertical	Horizontal	Horizontal

Table-4 (Theoretical value of Path Loss in free space)

Site No →	**1**	**2**	**3**	**4**	**5**
Path Loss(dB)	89.25	86.28	90.97	90.72	97.56

Table-5(Path Loss Due to Foliage)

Site No →	**1**	**2**	**3**	**4**	**5**
Path Loss in dB (practical value)	120.9	117.9	122.7	122.7	129.7
Path Loss in dB (Free space Model)	89.25	86.25	90.97	90.72	97.56
Path Loss due to foliage in HTE(dB)	31.65	31.65	31.73	31.98	32.14
Path Loss in dB/km	18.72	26.38	15.40	15.99	7.158

at 15 GHz frequency, when a pair of 36.6 dBi antenna is used .Actually, the loss which is being found because of the irregular structure of the terrain and forest can't be eliminated completely. But, it can be minimized by use of high EIRP and low return loss antenna [5-10] .Low return loss antenna with large bandwidth [8-11] is highly suitable and recommended in this region to receive the radio signal at low transmission power, though signal loss is high. It means in high path loss environment, the suggested antennas can be used for transmission purpose at very loss power.

V. CONCLUSION

In this paper the UHF radio waves in dense vegetation environment is investigated through the practical data which is taken very carefully.Result of the high resolution analysis reveals that nature of the tress, theirheight; shape and size of leaves and order of trees play the major roll in path loss determination. It is so difficult to suggest the exact empirical and statistical formula to calculate the accurate value of path loss in purely foliage or in hilly terrain areas .However, by taking so many observations at a single site from different angles, and same process were repeated for other site also. Then it is concluded that presence of foliage in hilly terrain zone increases the path loss significantly.

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