Study of Signal Loss with Frequency Variation by a Wireless Propagation Model

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***Abstract*— This paper presents the design of a propagation model such that the signal despite suffering from maximum attenuation does not go below threshold level for the decoder. At first we tally the experimental result with Lee model, Free space propagation model & Okumura-Hata path loss model. Then we design a new model.**

***Keywords*—Wireless Propagation, Optimization, Signal Loss, propagation model**

INTRODUCTION

The liberalization of the airwaves and official launching of the Digital Terrestrial television there is a trend of more private radio and television companies to operate in the country. The digital TV signal suffers from noise giving rise to problems. A decoder in general able to tolerate the loss. In field strength. Independently of the threshold noise level the decoder can tolerate, our aim is to design a propagation model such that the signal despite despite suffering from maximum attenuation does not go below threshold level for the decoder. The digital coverage has to be studied to obtain good QoS.

In the coming decades, the number of channels which will beam into homes and the number of potential signal paths to the consumer will multiply. Due to a more sophisticated multichannel environment, there will be an even larger number of separate processes and switching stages through which a radio or television signal will pass and at any moment one signal may fail or detrimentally affect the picture and sound quality, Hence the opportunity for faults and failures occur in between the broad caster and the consumer is increasing. It will become more and more difficult for a broad cast engineer to know whether a signal, after passing through all these separate process and transmission paths will teach the consumer in a correct audio and picture format. An alternative solution to the problems needs to be formed.

I. OVERVIEW OF THE PROPAGATION MODELS

A. Physical models: Physical models of path loss make use of physical radio waves principles such as free space transmission, reflection or diffraction.

B. Empirical models: Empirical models use measurement data to model a path loss equation. Examples of empirical propagation models include the ITU-R and the Hata models. Empirical models use what are known as predictors or specify in general statistical modeling theory (Saunders 2005). To conceive these models, a correlation was found between the received signal strength and other parameters such as antenna heights, terrain profiles etc through the use of extensive measurement and statistical analysis. Empirical path- loss models based on measuring the received signal strength as a function of distance while keeping other system parameters constant. Propagation path loss is the attenuation of the field intensity of a radio signal due to all factors influencing it along its radio path. The path loss is cost by many factors such as-multi-path propagation, reflection, refraction, diffraction, absorption, and so on. In practice, the path loss, that is, the signal loss from transmitted power to received signal level through the wireless medium depends on the propagation environment including the transmitter and receiver antenna heights. A path-loss exponent or distance-power or path-loss gradient, and a random component that signifies the fluctuations around the average path loss due to shadow fading effects and other similar reasons characterize most of the path-loss models. Prediction of path loss is an important element of system design in any communication system. In the radio and TV broadcast systems, the prediction of path loss is very important as the environment is constantly changing with time. A reliable propagation model is one which calculates the path loss with small standard deviation. This will, hence, help network engineers and planners to optimize the cell coverage size and to use the correct transmitted powers. Suitable models must be chosen for prediction. An accurate and reliable prediction method helps to optimize the coverage area, transmitter power and eliminates interference problems of other radio transmitters. All the prediction methods are divided into empirical and deterministic/physical models. Path loss can be defined as the ratio of the transmitted to received power, usually expressed decibels.

II. DESCRIPTION OF DIFFERENT PROPAGATION MODELS

A. Lee Model: The Lee model (1985) is a power law model with parameters taken from measurements in a number of locations. The model is expressed as follows:

$$L(suburban)(dB) = 10n \log d - 20 \log htx - Po - 10 \log hrx + 29$$

where n = 3.84 and Po=-61.7. Here it has been assumed that htx is the effective base station height.

B. *Free Space Propagation Model:* The free space propagation model is used to predict received signal strength when the transmitter and receiver have a clear, unobstructed line-of-sight path between them (Friis1946). As with most large scale radio wave propagation models, the free space model predicts that received power decays as a function of the Transmitter-Receiver separation distance raised to some power (i.e. a power law function) (Saunders 2005). The free space power received by a receiver antenna which is separated from a radiating transmitter antenna by a distance d, is given by the Friis free space equation

$$Pr(d)=(pt*gt*gr*c^2)/(4*pi*d*f)^2.$$

where *Pt* is the transmitted power, *Pr(d)* is the received power, *Gt* is the transmitter antenna gain, *Gr* is the receiver antenna gain, *d* is the T-R separation distance in meters and *λ* is the wavelength in meters. The Friis free space equation shows that the received power falls off as the square of the Transmitter-Receiver (T-R) separation distance. This implies that the received power decays at a rate of 20 dB/decade with distance. The path loss, which represents signal attenuation as a positive quantity measured in dB, is defined as the difference (in dB) between the effective transmitted power and the received power, and may or may not include the effect of antenna gains(ITU Report 1998). The path loss for the free space model when antenna gains are included is given by:

$$Pl(dB)=10log(pt/pr)=-10log((gt*gr*c^2)/((4*pi*d*f)^2).$$

C. *Okumura-Hata path loss model:* The simple modeling of path loss is still dominated by the **Hata empirical model** (Hata 1980), where the propagation results are fitted to a simple analytical expression, which depends on antenna height, environment, frequency and other parameters. Hata's method is basically an extension of Okumura's method (which is somewhat cumbersome due to numerous correction factors) and employs propagation curves instead of parametric equations. It is a model based upon an extensive series of measurements made in and around Tokyo city between 200 MHz and 2 GHz. Predictions are made via a series of graphs. The thoroughness of work has made the model the most widely used macro cell prediction model and is often regarded as a standard against which researchers can benchmark new approaches. The model for urban areas has been standardised in 1997 for international use as Rec ITU-R P.529 model (ITU Report 1997). The Hata model does not have any of the path-specific corrections which are available in Okumara's model. Okumura takes urban areas as a reference and applies correction factors for conversion to the classification of terrain. Hence the model will involve dividing the prediction area into a series of clutter and terrain categories as follows:

Open area: Open space, no tall trees or buildings in path, plot of land cleared for 300-400 m ahead, e.g. farm land, rice fields, open fields.

Suburban area: Village or highway scattered by trees and houses, some obstacles near the receiving antenna but not very congested;

Urban area: Build up city or large town with buildings and houses with two or more stories, or larger villages with close houses and tall and thickly grown trees.

The standard Hata formula for median path loss in urban areas is given by:

$$L(urban)(dB)= 69.55+ 26.16\log fc-13.82\log htx-a(hrx)+ (44.9-6.55\log htx)\log d \quad (1)$$

where:

fc is the frequency (in MHz) from 150 MHz to 1500 MHz,

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III. OBSERVATION OF DIFFERENT PROPAGATION MODEL USING MAT LAB

A. *Lee Model:*

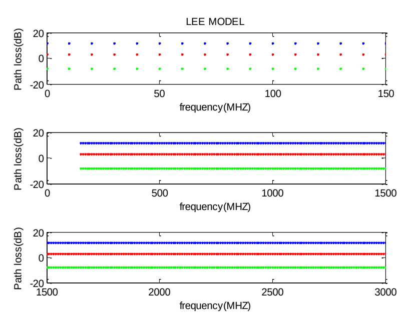

Figure:1 Lee Model

d=100cm(blue), d=80cm(red), d=60cm(green)

From the figure we can see that the path loss doesnot depend on frequewncy in different value of distance. It's remains almost constant.It has no frequency dependancy.So in this model we can work in different frequency range.

B. *Free space propagation model:*

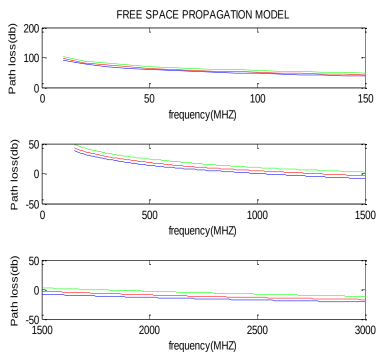

Figure:2 Free Space Propagation Model

d=100cm(blue), d=80cm(red), d=60cm(green)

The Friis free space equation shows that the received power falls off as the square of the transmitter receiver (t-r) separation distance. This implies that the received power decays at a rate of 20 db/decade with distance.

The path loss, whice represents signal attenuation as a positive quentity measured in db, is defined as the defference(in db) between the effective transmitted power and the received power, and may or may not included the effect of antenna gains (ITU Report 1998). From the figure we can see that the path loss depends on frequewncy in different value of distance. When the frequency increases the path loss remains almost constant but in lower frequency range the path loss varies with frequency.

C. *Okumura Hata Path loss Model:*

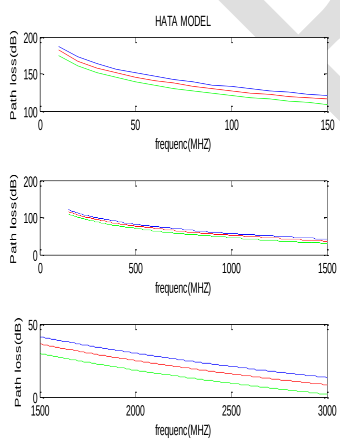

Figure:3 Okumura Hata Path loss Model:

d=100cm(blue),d=80cm(red), d=60cm(green)

The okumura hata model (1980) is an empirical formulation of the graphical path loss data provited by Okumura, and is valid from 150 MHz to 1500 MHz. The hata model is , basically, a set of equations based on measurements and extrapolations from the curves derived by okumura. Hata represented the urban area propagation loss as a standared formula, along with additional correction factors for application in other situations such as suburban and rural.

only four parameters are required in hata model.Hence the computation time is very short.This is an advantage of the model. However, the model neglects the terrain profile between the transmitter and receiver,that is hills or other obstacles between the transmitter and receiver are not considered.

From the figure we can see that the path loss depends on frequewncy in different value of distance. When the frequency increases the path loss remains almost constant but in lower frequency range the path loss varies with frequency.

RESULTS

A. *Comparison of different models with practical models*

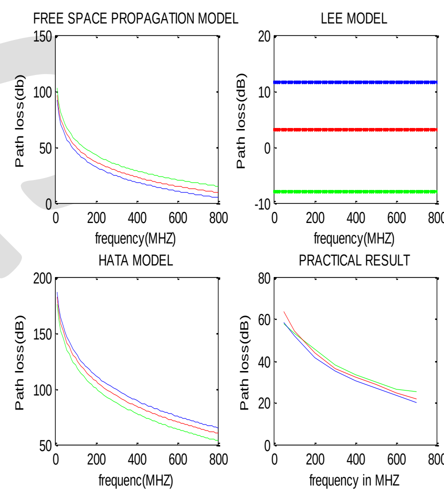

Figure:4 Comparison of different models with practical models

Table:1

Distance	Frequency (Mhz)	Free Space Model	Lee Model	Hata Model	Practical Model
		Path loss in dB			
100CM	100	46.2	11.69	132.3	52
	200	32.34	11.69	111.8	41.5
	300	24.23	11.69	98.92	35
	400	18.47	11.69	89.38	30.5
	500	14.01	11.69	81.75	26.85
	600	10.37	11.69	75.37	23.37
	700	7.283	11.69	69.87	19.99
80CM	100	50.66	3.121	127.3	54.05
	200	36.8	3.121	106.8	43.5
	300	28.69	3.121	93.87	36
	400	22.94	3.121	84.33	32.34
	500	18.47	3.121	76.71	28.5

	600	14.83	3.121	70.32	24.9
	700	11.75	3.121	64.83	21.75

60CM	100	56.42	-7.926	120.8	54.05
	200	42.55	-7.926	100.3	45.5
	300	34.45	-7.926	87.37	37.8
	400	28.69	-7.926	77.83	33.2
	500	24.23	-7.926	70.2	29.63
	600	20.58	-7.926	63.82	26.58
	700	17.5	-7.926	58.32	25

CONCLUSION

In this work the attempt is made to design a new propagation model minimizing the path loss for new broadcast network of tropical climate. Experimental study has been done on the location KOLKATA (22N30 88E20) . The result shown by Free-Space model is quite a similar nature compared to our experimental model, HATA model giving a large amount of path loss. AS the frequency increases the path loss gradually decreases and finally saturates after 450 MHZ.+50 is added as a bias value to the y-axis of the experimental model.The Yagi antenna is used over here for measurement. We take the distance 100cm(blue), 80cm(red),,60cm(green) for the experimental result. From the experimental model we have found an equation through MATLAB.

The equation is

Y=6.5e-005*x^2-0.099*x+62

Where y=path loss & x=frequency

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