Experiment Number:7

Roll Number	Class	Date of Performance	Date of Submission	Signature
42428	BE 8			

Title: Write a program to measure bit error rate in presence of Hata/ Multipath propagation model.

Aim: To measure bit error rate in presence of Hata/ Multipath propagation model.

Pre-requisites:

1. Hata/ Okumura model
2. Algorithm.

Apparatus:

1. PC with MATLAB Software.

Theory:

INTRODUCTION:

Wireless access network has becoming vital tools in maintaining communications especially at home and workplaces due to communication models. Propagation models can be classified mainly into two extremes, i.e. fully empirical models and Deterministic models. There are some models which have the characteristics of both types. Those are known as Semi-empirical models. Empirical models are based on practically measured data. Since few parameters are used, these models are simple but not very accurate. The models which are categorized as empirical models for macro cellular environment. These include Hata model, Okumura model, COST-231 Hata model. On the other hand, deterministic models are very accurate. Some of the examples include Ray Tracing and Ikegami model. As mentioned earlier, semi- empirical models are based on both empirical data and deterministic aspects. Cost-231 Walfisch-Ikegami model is categorized as a semi empirical model. All these models estimate the mean path loss based on parameters such as antenna heights of the transmitter and Receiver, distance between them, etc. These models have been extensively validated for mobile networks. Most of these models are based on a systematic interpretation of measurement data obtained in the service area .

G_{AREA}: gain due to type of environment given in suburban, urban or open areas Correction factors like terrain related parameters can be added using a graphical form to allow for street orientation as well as transmission in suburban and open areas and over irregular terrain. Irregular terrain is divided into rolling hilly terrain, isolated mountain, general sloping terrain and mixed land-sea path. The terrain related parameters that must be evaluated to determine the various corrections factors .

Path Loss:

Path loss is the degradation in received power of an electromagnetic signal when it propagates through space. Path loss is due to several effects such as free space path loss, refraction, diffraction, reflection, coupling and cable loss, and absorption. Path loss depends on several factors such as type of propagations, environments, distance between the transmitter and receiver, height and location of antennas. Also, the signal from the transmitting antenna may take multiple paths (multipath) to reach the receiving side, which results in either increase or decrease of received signal level depending on the constructive or destructive interference of the multipath waves.

Path loss is highly inevitable in evaluating networks quality and capacity as regards efficient and reliable coverage areas in the growth of mobile communication .

OKUMURA MODEL:

This is the most popular model that being used widely The Okumura model for Urban Areas is a Radio propagation model that was built using the data collected in the city of Tokyo, Japan. The model is ideal for using in cities with many urban structures but not many tall blocking structures. The model served as a base for Hata models. Okumura model was built into three modes which are urban, suburban and open areas. The model for urban areas was built first and used as the base for others. Clutter and terrain categories for open areas are there are no tall trees or buildings in path, plot of land cleared for 200-400m. For examples at farmland, rice fields and open fields. For suburban area the categories is village or highway scattered with trees and houses, few obstacles near the mobile. Urban area categories is built up city or large town with large buildings and houses with two or more storey or larger villager with close houses and tall, thickly grown trees.

Formula for Okumura Model is expressed below:

$L_m(dB) = L_F(d) + A_{mu}(f,d) – G(h_r) – G(h_t) – G_{AREA}$

Where;

L_m = (i.e., median) of path loss

$L_F(d)$ = free space propagation path loss.

$A_{mu}(f,d)$ = median attenuation relative to free space

$G(h_b)$ = base station antenna height gain factor

$G(h_m)$ = mobile antenna height gain factor $G(h_b)$

$= 20\log(h_b/200)$ $1000m > h_b > 30m$ $G(h_m)$

$= 10\log(h_m/3)$ $h_m <= 3m$

$G(h_m) = 20\log(h_m/3)$ $10m > h_m > 3m$

HATA MODEL:

Hata established empirical mathematical relationships to describe the graphical information given by Okumura. Hata's formulation is limited to certain ranges of input parameters and is applicable only over quasi-smooth terrain. The mathematical expression and their ranges of applicability are as follows

Carrier Frequency: 150 MHz $\leq f_c \leq$1500 MHz

Base Station (BS) Antenna Height: 30 m $\leq h_b \leq$200 m

Mobile Station (MS) Antenna Height: 1 m $\leq h_m \leq$10 m

Transmission Distance: 1 km $\leq d \leq$20 km

$A + B \log_{10}(d)$ for urban areas

L_p (dB) $= A + B \log_{10}(d) - C$ for suburban area

$A + B \log_{10}(d) - D$ for open area

Where:

$A = 69.55 + 26.161 \log_{10}(f_c) - 13.82 \log_{10}(h_b) - a(h_m)$

$B = 44.9 - 6.55 \log_{10}(h_b)$

$C = 5.4 + 2[\log_{10}(f_c / 28)]^2$

$D = 40.94 + 4.78 [\log_{10}(f_c)]^2 - 18.33 \log_{10}(f_c)$

Where, $a(h_m) =$

$[1.1\log_{10}(f_c) - 0.7] h_m - [1.56\log_{10}(f_c) - 0.8]$

for medium or small cities

$8.29[\log_{10}(1.54 h_m)]^2 - 1.1$

for large city and $f_c \leq 200$ MHz

$3.2 [\log_{10}(11.75 h_m)]^2 - 4.97$ for large city and $f_c \geq 400$ MHz

COST-231 MODEL:

Most future PCS systems are expected to operate in the 1800- 2000 MHz frequency band. It has been shown that path loss can be more dramatic at these frequencies than those in the 900 MHz range. Some studies have suggested that the path loss experienced at 1845 MHz is approximately 10 dB larger than those experienced at 955 MHz, all other parameters being kept constant. The COST231-Hata model extends Hata's model for use in the 1500-2000 MHz frequency range, where it is known to underestimate path loss. The model is expressed in terms of the following parameters ;

Carrier Frequency (f_c) $_{1500}$-2000 MHz

BS Antenna Height (hb) 30-200 m

MS Antenna Height (h_m) 1-10 m

Transmission Distance (d) 1-20 km

The path loss according to the COST-231-Hata model is expressed as:

L_p (dB) = A + B log10 (d) +C

Where;

A = 46.3+ 33.9 log10 (f_c) – 13.28 log10 (h_b) – a (h_m)

B = 44.9 – 6.55 log 10 (h_b)

C= 0 for medium city and suburban areas

3 for metropolitan areas

Calculation of Path loss:

The common representation formula of different communication models is ;

PL (d) = PL (d0) + 10nlog10 (d/d_0) where

d= Distance between Transmitter station and Mobile station

d_o= Reference point , n= Path loss exponent

Calculation of signal strength:

The Received Signal Strength Indicator (RSSI) or Signal Strength is a measure of how strong the most recent signal was when it reached its destination. The RSSI value ranges from 0 to 255. Higher RSSI values indicate a stronger signal. Reliable communication can best be achieved with RSSI values greater than 70. If the RSSI is too low the wireless communications may become intermittent or fail entirely. he received signal strength for Okumura model, Hat model and COST-231 model can be calculated as,

$$P_r = P_t + G_t + G_r - \text{PL} - \text{A}$$

Where

P_r is received signal strength in dB_m.

P_t is transmitted power in dB_m.

G_t is transmitted antenna gain in dB_m.

G_r is received antenna gain in dB_m.

PL is total path loss in dB_m.

A is connector and cable loss in dB_m.

In this work, connector and cable loss are not taken into consideration

Comparison of Okumura, Hata and Cost-231 models based on Path Loss:

Since attenuation is also the main cause of path loss which can be described as:

$A=16.5+15\log(f/100)-0.12d$

Where; f=frequency of operation, d=distance travelled.

Comparison of Okumura, Hata and Cost-231 models based on signal strength:

Since the comparison of communication models based on signal strength which considered the correction factor into account is

$C=(1.1\log f-0.7)h_m-(1.56\log f-0.8)$ Where; h_m=height of receiver antenna.

Conclusion:

The path loss of Okumura, Hata and Cost 231 models shows decreasing trend with respect to transmitter antenna height and receiver antenna height and increasing trend with respect to transmission distance. Among the communication models Okumura model shows the least path loss and Cost-231 model shows the largest path loss. The signal strength trends are opposite to that of path loss as signal strength with respect to transmitter antenna height and receiver antenna height shows increasing trend and decreasing trend with respect to transmission distance. The signal strength of Okumura model is largest in all the three cases and Cost-231 model shows the least signal strength. Among the three models Hata model shows intermediate results both in case of path loss and signal strength.

Signature:

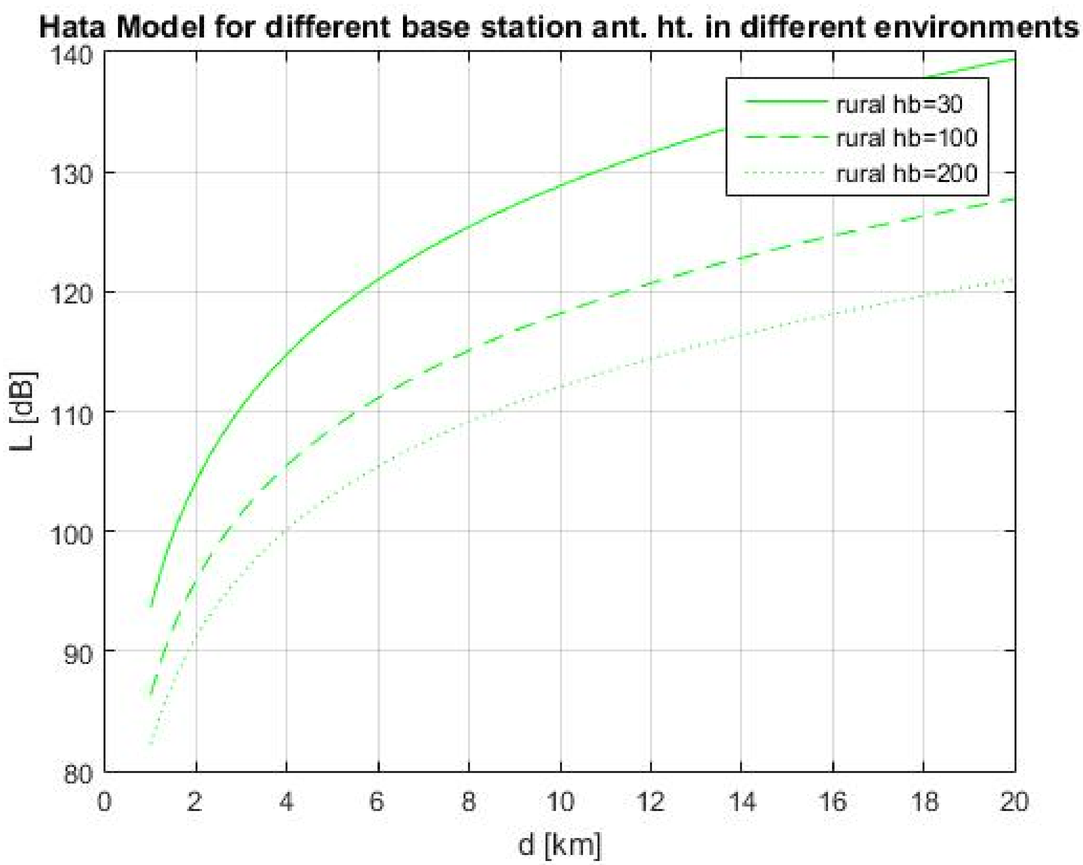
Date:

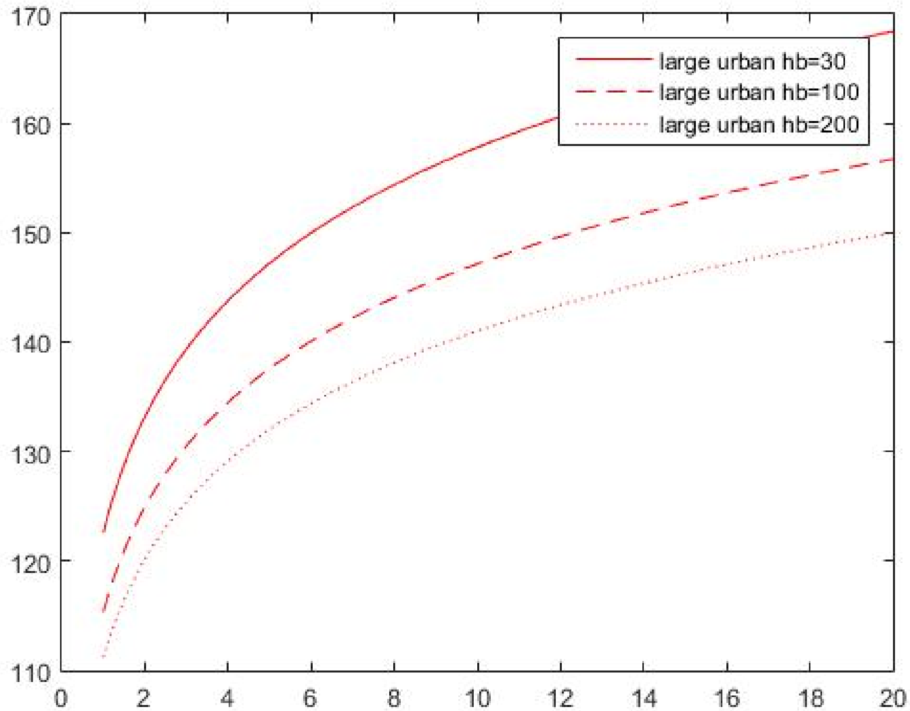
Code :

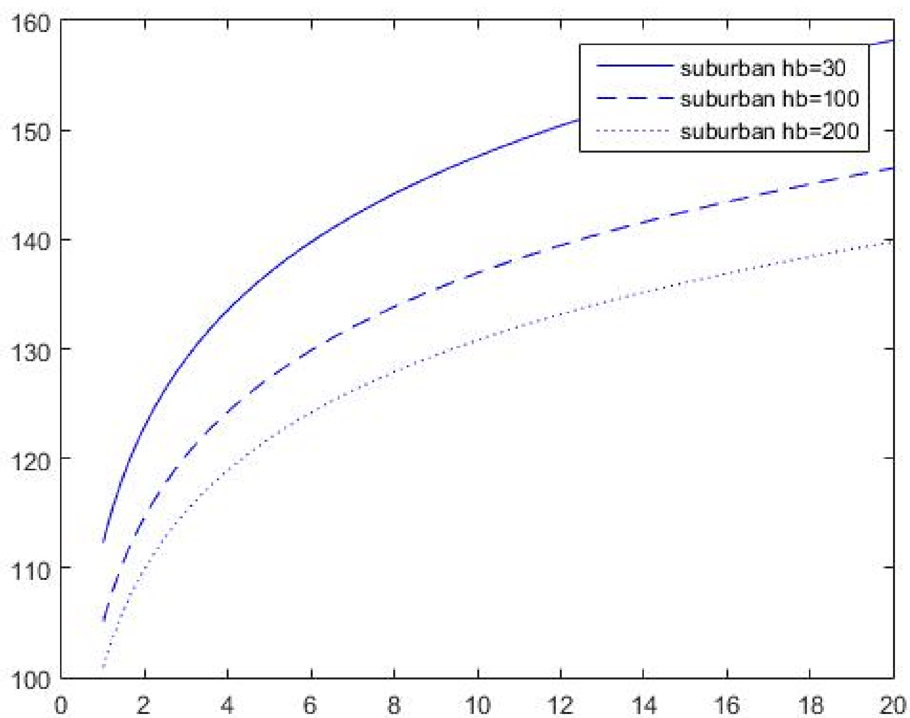
```
% Okumura/Hata Model 3
clc;
close all;
clear all;
d = 1:0.01:20;
hm = 5;
hb1 = 30;
hb2 = 100;
hb3 = 200;
fc = 1000;
% a. For Large Cities
% fc  >= 400MHz
ahm = 3.2*(log10(11.75*hm)).^2 - 4.97;
% A. Typical Urban
L50urban1 = 69.55 + 26.16*log10(fc) + (44.9 -
6.55*log10(hb1))*log10(d) - 13.82*log10(hb1) - ahm;
L50urban2 = 69.55 + 26.16*log10(fc) + (44.9 -
6.55*log10(hb2))*log10(d) - 13.82*log10(hb2) - ahm;
L50urban3 = 69.55 + 26.16*log10(fc) + (44.9 -
6.55*log10(hb3))*log10(d) - 13.82*log10(hb3) - ahm;
% B. Typical Suburban
L50suburban1 = L50urban1 - 2*(log10(fc/28)).^2 - 5.4;
L50suburban2 = L50urban2 - 2*(log10(fc/28)).^2 - 5.4;
L50suburban3 = L50urban3 - 2*(log10(fc/28)).^2 - 5.4;
% C. Typical Rural
L50rural1 = L50urban1 - 4.78*(log10(fc)).^2 + 18.33*log10(fc) -
40.94;
L50rural2 = L50urban2 - 4.78*(log10(fc)).^2 + 18.33*log10(fc) -
40.94;
L50rural3 = L50urban3 - 4.78*(log10(fc)).^2 + 18.33*log10(fc) -
40.94;
figure(1);
plot(d, L50urban1, 'r', d, L50urban2, '--r', d, L50urban3,':r');
hold on;
legend('large urban hb=30', 'large urban hb=100', 'large urban
hb=200');
figure(2);
```

```
plot(d, L50suburban1, 'b', d, L50suburban2, '--b', d, L50suburban3,
':b');
hold on;
legend('suburban hb=30', 'suburban hb=100', 'suburban hb=200');
figure(3);
plot(d, L50rural1, 'g', d, L50rural2, '--g', d, L50rural3, ':g');
hold on;
legend('rural hb=30', 'rural hb=100','rural hb=200');
grid on;
xlabel('d [km]');
ylabel('L [dB]');
title('Hata Model for different base station ant. ht. in different
environments');
```

Output :




large urban hb=30
large urban hb=100
large urban hb=200
170
160
150
140
130
120
110
0
2
4
6
8
10
12
14
16
18
20


suburban hb=30
suburban hb=100
suburban hb=200
160
150
140
130
120
110
100
0
2
4
6
8
10
12
14
16
18
20

Answer the following Questions on Separate Sheets

1.Write expression for net signal power at the receiver?

Ans.-

The link-budget expression for the SNR required is given as:

$$SNR_{req} = P_t(dB) + G_t(dB) - L(dB) - M(dB) + G_r(dB) - L_c(dB) - (N+I)dB$$

$SNR_{req} = net\ signal\ power\ at\ the\ receiver$

$G_t = Transmit - antenna\ gain$

$L = Median - link - propogation$ Loss

M=Margin

$G_r = Mobile - receive\ antenna\ gain$

$L_c = Cabling$ losses

$N + I = \mathrm{Re}\,ceiver(noise + interference)$

The above equation can be recast to compute the required transmit power as:

$$P_t(dB) = SNR_{req} - G_t(dB) + L(dB) + M(dB) - G_r(dB) + L_c(dB) + (N+I)dB$$

2.List and brief three basic propogation mechanism that impact propogation in mobile communication system.

Ans.-

Reflection, diffraction and scattering are the three basic propagation mechanisms that impact propagation in mobile communication systems.

Reflection

Reflection occurs when a propagating electromagnetic wave impinges upon an object that has very large dimensions compared to the wavelength of propagating wave. Reflection occurs from the surface of the ground, from walls, and from furniture. When reflection occurs, the wave may also be partially refracted. The coefficients of reflection and refraction are functions of material properties of the medium, and generally depend on the wave polarization, the angle of incidence, and the frequency of propagation wave.

Diffraction

Diffraction occurs when the radio path between the transmitter and receiver is obstructed by a surface that has sharp edges. The waves produced by the obstructing surface are present throughout space and even behind the obstacle, giving rise to the bending of waves around the obstacle, even when a Line of Sight (LOS) path does not exist between the transmitter and receiver. At high frequencies, diffraction-like reflection-depends on the geometry of the object, as well as on the amplitude, phase and polarization of the incident wave at the point of diffraction.

Scattering

Scattering occurs when the medium through which the wave propagates consists of objects with dimensions that are small compared to the wavelength, and where the number of obstacles per unit volume is large. Scattered waves are produced by rough surfaces, small objects, or by other irregularities in the channel. In practice, foliage, street signs, lampposts and stairs within buildings can induce scattering in mobile-communication systems. A sound knowledge of the physical details of the objects can be used to accurately predict the scattered signal strength.

3.Derive an expression of received power for Free space propogation model.

Ans.-

4.List factors influencing small scale fading.

Ans.-

Multipath propagation:

Reflecting objects and scattering in the channel creates a constantly changing environment that dissipates the signal energy in amplitude, phase and time. This results in multiple version of transmitted signal that arrive at the receiving antenna, displaced with respect to one another in time and space.

Speed of mobile:

The relative motion between the base station and the mobile results in random frequency modulation due to different Doppler shifts on each of the multipath components. Doppler shift is positive if mobile receiver is moving toward the base station and is negative if mobile receiver is moving away from the base station.

Surrounding of mobile:

If objects in the radio channel are in motion, they induce varying Doppler shift on multipath components. If the surrounding objects move at a greater rate than the mobile, then this effect dominates the small-scale fading. Otherwise motion of surrounding objects can be ignored.

Transmission bandwidth of signal:

If transmitted radio signal bandwidth is greater than the bandwidth of the multipath channel, the received signal will be distorted but the received signal strength will not fade much over a local area. If transmitted radio signal bandwidth is less than the bandwidth of the multipath channel, the received signal will not be distorted but the received signal strength will change rapidly. Bandwidth of the channel is quantified by the coherence bandwidth which is related to specific multipath structure of the channel. Coherence bandwidth is measure of maximum frequency difference for which signals are strongly correlated in amplitude