Computer Analysis for Path Loss Estimation

*Irving Alejandro Vega Lagunas*

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*Universidad Iberoamericana, Ciudad de México, 01210, México*

**Abstract — In this document, different propagation models are shown, such as the Okumura-Hata model, the COST 231 extension to the Hata model, the provisional model of Stanford University (SUI)**

**In addition, a comparative analysis of these models will be made in different circumstances to select the appropriate model for a specific scenario.**

# Introduction

Path loss, or path attenuation, is the reduction in power density of an electromagnetic wave as it travels through space is caused by the obstacles between transmitter and receiver. Path loss is an important component in the analysis and design of the link budget of a telecommunications system.

# Path Loss Models

# There are different propagation models which use different parameters such as the frequency of the signal, the height of the transmission and reception tower, as well as the terrain in which it is located, such as urban, suburban and rural.

# These models are used to measure the path loss and thus know what height is needed for the base stations.

# Okumura Hata

Developed by Masaharu Hata in 1980 and based on the results of measurements carried out by Yoshihisa Okumura in the city of Tokyo, Japan, it consists of a set of equations that allows estimating propagation losses in different types of areas (urban, semi-urban and open or rural). It is one of the most widely used models in the planning and sizing of the propagation segment of wireless telecommunications systems.

Coverage

* *Frequency: 150 – 1500 MHz*
* *Mobile station antenna height: 1 – 10 m*
* *Base station antenna height: 30 – 200 m*
* *Link distance: 1–20 km*

For small or medium sized cities.

For Large cities

Where:

* = Path loss in Urban Areas in decibels (dB)
* = Height of base station antenna in meters (m)
* = Height of mobile station antenna in meters (m)
* = Frequency of Transmission in megahertz (MHz)
* = Antenna height correction factor
* d = Distance between the base and mobile stations in kilometers (km)

For Suburban Areas

Where:

* = Path loss in Suburban Areas in decibels (dB)
* = Path loss in Urban Areas in decibels (dB)
* = Frequency of Transmission in megahertz (MHz)

For Open Areas

Where:

* = Path loss in Suburban Areas in decibels (dB)
* = Path loss in Urban Areas in decibels (dB)
* = Frequency of Transmission in megahertz (MHz)

# COST 231

The COST Hata model is a propagation model that expands on the urban Hata model, which is based on the Okumura model.

It is the most cited among the projects of COST 231, this model is a blend of empirical and deterministic approaches in the evaluation of path loss in urban areas within the 800 MHz to 2000 MHz frequency range.

Coverage

* *Frequency: 800 – 2000 MHz*
* *Mobile station antenna height: 1 – 10 m*
* *Base station antenna height: 30 – 200 m*
* *Link distance: 1–20 km*

For Urban environments

Where:

* = Path loss in Urban Areas in decibels (dB)
* = Height of base station antenna in meters (m)
* = Height of mobile station antenna in meters (m)
* = Frequency of Transmission in megahertz (MHz)
* d = Distance between the base and mobile stations in kilometers (km)

For Suburban Areas and Open Areas

Where:

* = Path loss in Suburban Areas in decibels (dB)
* = Height of base station antenna in meters (m)
* = Height of mobile station antenna in meters (m)
* = Frequency of Transmission in megahertz (MHz)

# Stanford University Interim (SUI)

This model is evolved as a part of IEEE 802.16 by Stanford University. This model uses frequency spectrum between 2.5GHz and 2.7GHz. The antenna height of the base station is between 15m to 40m, and the height of receiver is between 2m to 10m. The difference of this model is that covers three categories terrain namely:

Category A , Category B, Category C

* *Category A – Presents high path loss and suitable for hilly environment with moderate to heavy tree densities.*
* *Category B – distinguished with either flat terrains or hilly areas with rare vegetation or flat terrain with high vegetation.*
* *Category C – Presents low path loss and useful for flat terrain with moderate to heavy densities.*

Coverage

* *Frequency: 2.5 – 2.7 MHz*
* *Mobile station antenna height: 2 – 10 m*
* *Base station antenna height: 15 – 40 m*
* *Link distance: 1–20 km*

*Tabla 1:*

*PARAMETERS VALUES FOR SUI IN DIFFERENT TYPES OF TERRAINS.*

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | A | B | C |
| a | 4.6000 | 4.0000 | 3.6000 |
| b | 0.0075 | 0.0065 | 0.0500 |
| c | 12.600 | 17.100 | 20.000 |
| Sh | 10.600 | 9.600 | 8.2000 |

Path attenuation equation.

Where:

* = Free space path loss
* = Reference distance 100(m)
* = Path attenuation exponent value
* = Frequency correction factor
* = Receiving antenna correction factor
* = Correction factor for shadowing (dB)
* d = Distance between the base and mobile stations in kilometers (km)
* f = frequency
* = is the Antenna height of CPE
* = is the Antenna height of base station

Where Fs, is calculated by:

* γ > 5 for indoor propagation
* 3 < γ < 5 for urban Non-Line of Sight (NLoS) environment
* γ = 2 for free space path loss

For Terrain Category A and B:

Interfaz de usuario gráfica

Descripción generada automáticamente

*Figura 0: Computer Application of loss models.*

In the application we can choose between the different models of path loss, in addition to choosing what we want to graph, such as the loss against distance and how it is affected by the different models.

In addition to this we have other values such as how it affects the height of the base station with a distance defined by the user.

An additional option is to plot the loss against the frequency.

Git Hub Repository:

<https://github.com/IrvingAlx/Path_Loss_Modeels.git>

# Results

Once the application was modeled, we can take the measurements of different cases for each of our models, which are shown below.

**Okumura Hata LOSS -vs Distance**

Interfaz de usuario gráfica

Descripción generada automáticamente

*Figure 1: Okumura-Hata 700mHz 35m 3m*

Interfaz de usuario gráfica

Descripción generada automáticamente

*Figure 2: Okumura-Hata 1200mHz 35m 3m*

Interfaz de usuario gráfica

Descripción generada automáticamente

*Figure 3: Okumura-Hata 1900mHz 35m 3m*

**COST 231 LOSS -vs Distance**

Interfaz de usuario gráfica

Descripción generada automáticamente

*Figure 4: COST-231 700mHz 35m 3m*

Interfaz de usuario gráfica

Descripción generada automáticamente

*Figure 5: COST-231 1200mHz 35m 3m*

Interfaz de usuario gráfica

Descripción generada automáticamente

*Figure 6: COST-231 1900mHz 35m 3m*

**SUI LOSS -vs Distance**

Interfaz de usuario gráfica

Descripción generada automáticamente

*Figure 7: SUI 700mHz 35m 3m*

Interfaz de usuario gráfica

Descripción generada automáticamente

*Figure 8: SUI 1200mHz 35m 3m*

Interfaz de usuario gráfica

Descripción generada automáticamente

*Figure 9: SUI 1900mHz 35m 3m*

**Okumura Hata LOSS -vs Hb**

Interfaz de usuario gráfica

Descripción generada automáticamente

*Figure 10: Okumura-Hata 700mHz 35m 7km*

Interfaz de usuario gráfica

Descripción generada automáticamente

*Figure 11: Okumura-Hata 1200mHz 35m 7km*

Interfaz de usuario gráfica

Descripción generada automáticamente

*Figure 12: Okumura-Hata 1900mHz 35m 7km*

**Cost 321 LOSS -vs Hb**

Interfaz de usuario gráfica

Descripción generada automáticamente

*Figure 13: COST 231 700mHz 35m 7km*

Interfaz de usuario gráfica

Descripción generada automáticamente

*Figure 14: COST 231 1200mHz 35m 7km*

Interfaz de usuario gráfica

Descripción generada automáticamente

*Figure 15: COST 231 1900mHz 35m 7km*

**SUI LOSS -vs Hb**

Interfaz de usuario gráfica

Descripción generada automáticamente

*Figure 16: SUI 700mHz 35m 7km*

Interfaz de usuario gráfica

Descripción generada automáticamente

*Figure 17: SUI 1200mHz 35m 7km*

Interfaz de usuario gráfica

Descripción generada automáticamente

*Figure 18: SUI 1900mHz 35m 7km*

**Okumura Hata LOSS -vs f**

Interfaz de usuario gráfica

Descripción generada automáticamente

*Figure 19: Okumura-Hata 700mHz 3m 7km*

Interfaz de usuario gráfica

Descripción generada automáticamente

*Figure 20: Okumura-Hata 1200mHz 3m 7km*

Interfaz de usuario gráfica

Descripción generada automáticamente

*Figure 21: Okumura-Hata 1900mHz 3m 7km*

**Cost 321 LOSS -vs f**

Interfaz de usuario gráfica

Descripción generada automáticamente

*Figure 22: COST 231 700mHz 3m 7km*

Interfaz de usuario gráfica

Descripción generada automáticamente

*Figure 23: COST 231 1200mHz 3m 7km*

Interfaz de usuario gráfica

Descripción generada automáticamente

*Figure 24: COST 231 1900mHz 3m 7km*

**SUI LOSS -vs f**

Interfaz de usuario gráfica

Descripción generada automáticamente

*Figure 25: SUI 700mHz 3m 7km*

Interfaz de usuario gráfica

Descripción generada automáticamente

*Figure 26: SUI 1200mHz 3m 7km*

Interfaz de usuario gráfica

Descripción generada automáticamente

*Figure 27: SUI 1900mHz 3m 7km*

*Table 2: Maximum allowable losses*

|  |  |  |
| --- | --- | --- |
| Model | Environment | Maximum Loss |
| Okumura-Hata | Open | -91.405 dB |
| Okumura-Hata | Suburban | -111.03 dB |
| Okumura-Hata | Urban | -122.34 dB |
| COST 231 | Open | -422 dB |
| COST 231 | Suburban | -422 dB |
| COST 231 | Urban | -131 dB |
| SUI | Open | -352 dB |
| SUI | Suburban | -354 dB |
| SUI | Urban | -355 dB |

# Conclusions

# In this paper, we examine different propagation path models. By means of an application developed in java to calculate the attenuation of the route in different areas, that is, rural, suburban, and urban.

# In addition to this we will use different models such as Okumura-Hata, COST 231 and SUI.

# With these results we can see how there is a different application for the models, this is because each model has different parameters, also in which cases one is more useful than the other.

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