Okumura & Hata Path Loss models

Snigdha Sinha
1351182022
ECE-AI (2)

Introduction

01. Path loss models estimate signal attenuation over distance.
02. Essential for cellular planning, coverage prediction, and frequency reuse.
03. Two widely used empirical models:
    a) Okumura Model (1968, Japan)
    b) Hata Model (1980, analytical expression of Okumura)

Okumura Path Loss Model

- Based on extensive field measurements (150 MHz – 1920 MHz, up to 100 km).
- Applicable for urban, suburban, and open areas.
- General formula:

$$P_L\ (dB) = L_f + A_{m,n}(f,d) - G(h_t) - G(h_r) - G_{AREA}$$

L_f: Free space path loss

$A_{m,n}(f,d)$: Median attenuation relative to free space

$G(h_t), G(h_r)$: Base station & receiver antenna height gains

G_{AREA}: Environment correction factor

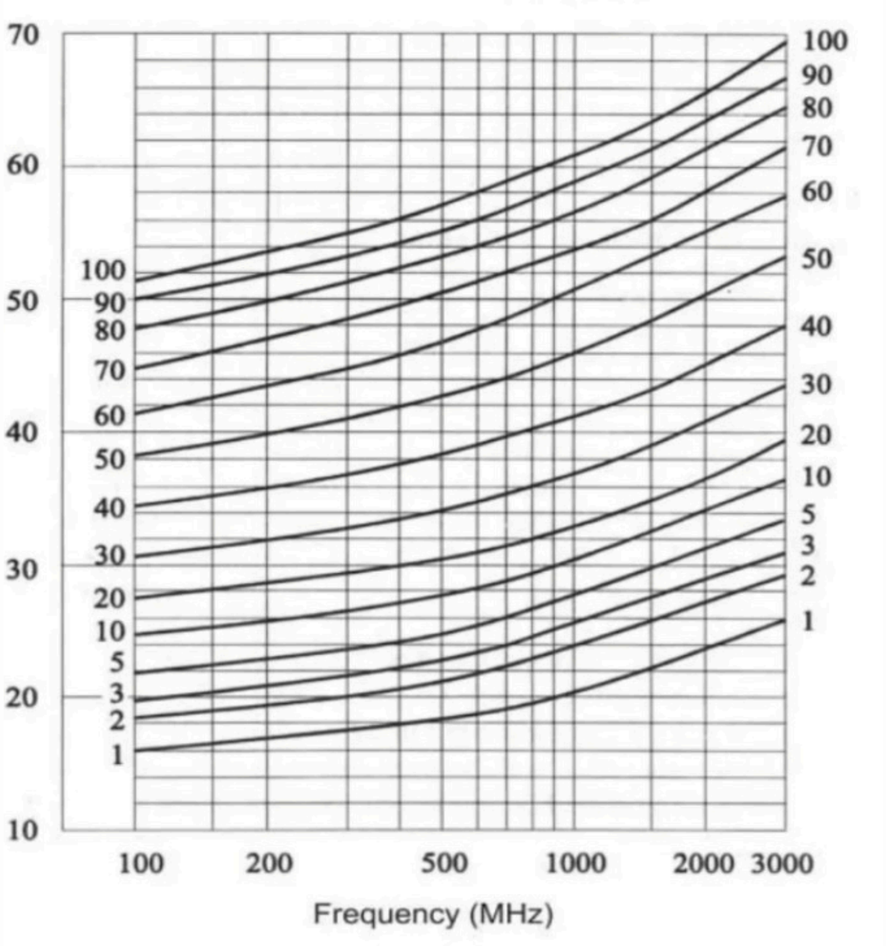
Okumura Model (free space loss)

$$L_{FS} = 32.45 + 20\log\left(\frac{d}{1\,\text{km}}\right) + 20\log\left(\frac{f}{1\,\text{MHz}}\right) - 10\log(G_t) - 10\log(G_r)$$

- $\boldsymbol{d}$ Distance between the TX and RX in km
- $\boldsymbol{f}$ Operating frequency in MHz
- $\boldsymbol{G_t}$ TX antenna gain (linear)
- $\boldsymbol{G_r}$ RX antenna gain (linear)
- The remaining terms of **Okumura Model** are provided in a **graphical form** as the family of curves.

Okumura Model

- It models additional propagation losses due to the signal propagation with these **referenced** conditions:
  - Terrestrial **Urban** environment over a quasi-smooth terrain.
  - Base station **Effective** antenna height $\boldsymbol{h_{te} = 200\ m}$
  - **Mobile** antenna height $\boldsymbol{h_{re} = 3\ m}$.
- If the actual heights of the TX and RX or the propagation area type differ from those referenced, the **appropriate correction** needs to be added.



Hata Model

- The Hata model is the empirical formulation of the graphical path loss data provided by Okumura and valid from 150 MHz to 1.5 GHz
- Although, Hata's model does not have any of the path specific corrections which are available in Okumura model
- Prediction of Hata's model compare very closely with the original Okumura model as long as d exceeds 1 km.

Hata Path Loss Model

- Empirical formulation of Okumura’s curves (150–1500 MHz).
- More practical for calculations
- Urban area model

$$P_L urban(dB) = 69.55 + 26.16 \log10(f) - 13.82 \log10(h_t) - a(h_r) + [44.9 - 6.55 \log10(ht)] \log10(d)$$

f: frequency in MHz (150–1500 MHz)

h_t: transmitter height (30–200 m)

h_r: receiver height (1–10 m)

d: distance (1–20 km)

Okumura-Hata Model (Pros and Cons)

- It was derived as a numerical fit to the curves published by Okumura. As such, the model is somewhat **specific to Japan's** propagation environment.
- It assumes that there are **no dominant obstacles** between the BS and the MS, and that the **terrain profile changes only slowly**.
- Measurements have shown several **disadvantages** to the approach for **effective antenna height** calculation. To circumvent the problem, some **prediction tools** examine **alternative methods** for calculation of the effective antenna height.
- Parameter range **does not encompass** the **1800 MHz** frequency range most commonly used for 2G and 3G cellular systems. *(This was solved by the **COST 231-Hata model**)*

Thank You!