Okumara and Hata Model

Gain & weight

$G = 20\log\left(\frac{h_{te}}{200}\right)$ $100\,m > h > 30m$

$G(h_{re}) = 10\log\left(\frac{h_{re}}{3}\right)$ $h_r \leq 3m$

$G(h_{re}) = 20\log\left(\frac{h_{re}}{3}\right)$ $10m > h_r > 3m$

→ Okumara model → path loss prediction model

$L_{50}(dB) = L_F + A_m(f, d) - G(h_{te}) - G(h_{re}) - G_{area}$

→ Hata and extended Hata model

$L_{50}(dB) = 69.55 - 26.16\log f_c\,(MHz) - 13.82\log h_{te} - a(h_{re}) + (44.9 - 6.55\log h_{te})\log d.$

h_{te} - BS height of antenna (30 to 200m)

h_{re} - mobile antenna height (1m to 10m)

$a(h_{re})$ - is a correction factor for effective mobile antenna

$a(h_{re}) = 8.29(\log 1.54h_{re})^2 - 1.1dB$ $f_c \leq 300MHz$

$a(h_{re}) = 3.2(\log 11.75h_{re})^2 - 4.97dB$ $f_c \geq 300MHz$

(for large sized city.

$L_{50}(dB) = L_{50}(urban) - 2[\log(f_c/28)]^2 - 5.4.$

⇒ Extended Hata model

Scanned by CamScanner

1) Employing the okumara model compute the median loss at a distance of 10 km when the carrier frequency (Fc) is 2.1 GHz. Assume hte = 40m, hre = 2m, for a large city. If EIRP is given by 1kW at the carrier frequency. Find the recieved power for the same scenario.

Soln:- $L_{50}(dB) = L_F + A_{mu}(f,d) - G(h_{te}) - G(h_{re}) - G_{area}$

L_{50} — 50th percentile value (median) of the path loss

L_F — freespace propagation loss

A_{mu} — median attenuation relative to freespace

G_{area} — gain

$\therefore f_c = 2.1 GHz, \quad h_{te} = 40m, \quad h_{re} = 2m,$

$$L_F = -10\log\left(\frac{\lambda^2}{(4\pi)^2 d^2}\right) \simeq 10\log\left(\frac{d^2(4\pi)^2}{\lambda^2}\right)$$

$$\therefore \lambda = \frac{c}{f} = \frac{1}{7} = 0.143 \text{ m}$$

$$\therefore L_F = 10\log\left(\frac{10^2 \times 10^6 \times 4\pi^2}{0.143^2}\right)$$

$= 118$ dB

$$\therefore G_{hte} = 20\log\left(\frac{h_{te}}{200}\right) = -13.97 \text{ dB}$$

$$G_{re} = 10\log\left(\frac{h_{re}}{3}\right) = -1.76 \text{ dB} \quad \because h_{re} = 2m < 3m$$

$A_{mu}(2.1, 10km) = 34$ dB (from graph)

G_{area}, area - large city

$\therefore G_{area} = 0$

$\therefore L_{50}dB = 118 + 34 + 13.97 + 1.76$

$L_{50}dB = 167.73\,dB \rightarrow$ okumara model

Hata Model :-

$f_c = 2.1\,GHz = 2100\,MHz$

$$L_{50}dB = 69.55 + 26.16\log(f_c)_{\text{in MHz}} - 13.82\log h_{te} - a(h_{re}) + (44.9 - 6.55\log(h_{te}))\log(d)$$

$\therefore a(h_{re}) = ? = 3.2(\log(11.75 \times h_{re}))^2 - 4.97$

$= 1.045\,dB$

$$L_{50}dB = 69.55 + 26.16\log(2100) - 13.82\log 2\text{[?]} - 1.045 + (44.9 - 6.55\log 10\text{[?]})\log(40)$$

$= 69.55 + 86.9 - 22.14 - 1.045 + 137.6$

$= \cancel{288}\,dB\ \ 271\,dB$

power

$P_R = P_t - L_{50}$

$P_tG_t = EIRP$ considering $G_t = 1$

$\therefore EIRP = P_t = 1\,kW = 10\log\left(\frac{1 \times 10^6}{mW}\right) = 60\,dBm$

$P_R = 60\,dBm - 167\,dB = \cancel{167\,dB}$ $dBm = dB + 30$

$= 30\,dB - 167\,dB$

$= -137\,dB$

) determine the propagation path loss for a radio signal at 800 MHz with Tx antenna height of 30 m, $h_r = 2m$, $d = 10$ Km over a dense urban mobile environment, using Hata model propagation loss. If free space path loss is 110.5 dB, how is hata propagation path loss comparable with that of free space.

Soln:- $\therefore h_{re} = 2m$

$$L_{50}dB = 69.55 + 26.16 \log f_c \text{ (MHz)} - 13.82 \log h_{te} - a(h_{re}) + (44.9 - 6.55 \log h_{te}) \log d$$

$$a(h_{re}) = 3.2 (\log 11.75 h_{re})^2 - 4.97$$

$$= 3.2 (\log 11.75 \times 2)^2 - 4.97$$

$$= 1.045$$

$$\therefore L_{50}dB = 69.55 + 75.94 - 20.41 - 1.045 +$$

140.89

$$= 264.925 \simeq 265 \text{ dB}$$

$$L_F = 110.5 \text{ dB (free space)}$$

$$L_{50}dB >> L_F$$

$\because$ shadowing
multipath effects.

The power recieved from an antenna radiating P_T watts in free space given by:

$$P_R = P_T G_T G_R \left(\frac{\lambda}{4\pi d}\right)^2 \quad , P_R = \frac{P_o}{d^2}$$

G_T - transmitting } antenna link gain
G_R - recieving }

λ - signal wavelength

d - distance from txn antenna

Ex1:- $P_T = 1W$,
$f_c = 1900 MHz$ $\therefore \lambda = \frac{c}{f} = \frac{3\times10^8}{19\times10^8} = 0.157$

$d = 1000\ m$

$G_T = G_R = 1.6$, path loss = ?

$$P_o = \frac{1\times1.6\times1.6\times(0.157)}{(4\pi)^2} = 0.000399\ W = 0.399\ mW$$

$$10\log\left(\frac{P_o}{1m}\right) = 4.08\ dBm$$

Now, $d = 1000\ m$

$$\therefore P_R = \frac{P_o}{d^2} = \frac{0.399\ m}{1000^2} = 0.399\ nW = -63.9\ dBm$$

Path loss in dB is

$$\text{Path loss} = P_T - P_R$$
$$= 30\ dBm - (-63.9\ dBm)$$
$$\boxed{\text{Path loss} = 93.9\ dBm}$$

2) $P_T = 120\,watt = 10\log\left(\frac{120}{1m}\right) = 50.79\ dBm$

$G_T = 34dB,$

$G_R = 33dB,$

$f_c = 12.45\,GHz = 12450\,MHz$

$\lambda = \frac{c}{f} = \frac{3\times10^8}{12450\times10^6} = 0.024\,m$

$\therefore P_R = P_T + G_R + G_T - 20\log\left(\frac{4\pi d}{\lambda}\right)$

$= 50.8\,dBm + 34dB + 33dB - 20\log\left(\frac{4\pi\times35786000}{0.024}\right)$

$\boxed{P_R = -87.65\ dBm,}$

$P_T = 16\ dBm,$

3) $f = 38\,GHz = 38000\,MHz,$

$G_T = G_R = 38.5\,dB, \quad d = ?$

reciver sensitivity $= -74\,dBm$

$P_R = P_T + G_T + G_R - 20\log\left(\frac{4\pi d}{\lambda}\right)$

$= 16 + 38.5 + 38.5 - 20\log\left(\frac{4\pi d}{\lambda}\right)$

link margin $= 15\,dB,$

received signal power $= -74\,dBm + 15$

$= -59\,dBm = P_R$

$-59 = 93\,dBm - 20\log\left(\frac{4\pi d}{\lambda}\right)$

$\lambda = \frac{c}{f} = \frac{300}{38000} = 0.00789\times$ m

$152 = 20\log\left(\frac{4\pi d}{7.89\times10^{-3}}\right)$

$\Rightarrow 39.81\times10^6 = \frac{4\pi d}{7.89\times10^{-3}}$

$d = 24995\,m = 25\,km.$