End Problem 4.8

(a) Explain the advantages and disadvantages of the two ray ground reflection model in the analysis of path loss?

(b) In the following cases, tell whether the two ray model could be applied, and explain why or why not:

$$h_t = 35m, \; h_r = 3m, \; d = 250m$$

$$h_t = 30m, \; h_r = 1.5m, \; d = 450m$$

(c) What insight does the two ray model provide about large-scale path loss that was disregarded when cellular systems used very large cells?

Sol.

(a) Advantages

It considers both the direct path and ground reflected propagation path between transmitter and receiver.

Disadvantages

This model is oversimplified. It does not include important factors such as terrain profile, vegetation and buildings.

(b) Generally when $d > 10(h_t + h_r)$, we may apply two ray model

for $h_t = 35m$, $h_r = 3m$, $d = 250m$

$$d > 10(h_t + h_r)$$
$$250 > 10(35+3)$$
$$250 > 380 \quad \text{false}$$

Hence, two ray model could not be applied

for $h_t = 30m$, $h_r = 1.5m$, $d = 450m$

$$d > 10(h_t + h_r)$$
$$450 > 10(30 + 1.5)$$
$$450 > 315 \quad \text{True}$$

Hence, the two ray model could be applied.

(c)

Using the two ray model, we can see that at large distances, the received power falls off with distance raised to the fourth power or at a rate of 40 dB/decade, and the received power and path loss are independent of frequency.

———.

Exercise / end Problem: 4.14

~~Assuming~~ Assuming a receiver is located 10 km from a 50 W transmitter. The carrier frequency is 1900 MHz, free space propagation is assumed $G_t = 1$ $G_r = 2$ find (a) the Power at the receiver (b) magnitude the E-field of the receiver antenna (c) open ccit rms voltage applied to receiver I/P assuming that the receiver antenna has a purely real impedance of 50 Ω and is matched to the receiver (d) Find the received Power at the mobile using the two-ray ground reflection model assuming the height of ~~transm~~ transmitting ~~ant~~ antenna is 50 m and receiving antenna is 1.5 m above the ground and ground reflection is −1.

Sol.

$\lambda = c/f = 0.1579\,m$ $\qquad \lambda = \frac{c}{f} = \frac{3\times10^8}{1900\times10^6} =$

$d = 10$ km $\qquad G_t = 1$

$P_t = 50$ W $\qquad G_r = 2$

$f = 1900$ MHz $\qquad$ Tx Antenna ht = 50 m $\quad$ Rx $h_r = 1.5$ m

~~Gt~~

$$P_r(d) = 10\log_{10}\frac{P_t G_t G_r \lambda^2}{(4\pi d)^2} = 10\log_{10}\frac{50\times1\times2\times0.1579}{(4\pi\times10000)^2}$$

$$= 10\log_{10}(1.58\times10^{-10})$$

$$= -98\,dBW = -68\,dBm$$

(b) $A_e = G_r\,\lambda^2/4\pi$ (4) $P_r(d) = \frac{|E|^2}{120\pi}A_e$ $\qquad \Big\| \; A_e = \frac{G\lambda^2}{4\pi}$

$$|E| = \sqrt{\frac{P_r(d)\,120\pi}{G_r\lambda^2/4\pi}} = 3.67\,mV/m$$

(c) $V = \sqrt{P_r(d)\times4R_{ant}} = \sqrt{1.58\times10^{-10}\times4\times50} = 0.178\,mV$

(d): In order to use the 2-ray model approximation, the following condition must be held.

$$\rightarrow d > \frac{20 h_t h_r}{\lambda} = \frac{20\times50\times1.5}{0.1579} = 9500\,m \quad (9499 \approx)$$

cf — 4.50 on page 124

Since d = 10,000 m, we can use the following equations for the 2-ray ground reflection model

$Pr(W) = P_t G_t G_r \times \frac{h_t^2 h_r^2}{d^4}$ ——— eq. 4.52 on page 124

$= 50 \times 1 \times 2 \times \frac{50^2 \times 1.5^2}{(10000)^4} = 5.625 \times 10^{-11} W$

$Pr(dBm) = -72.5 \ dBm$

$-98 = 10 \log_{10}$

$\frac{-98}{10} = \log_{10}$

$-9.8 = \log_{10}$

$10^{-9.8} = \log W$

$W = 1.58 \times 10^{-10}$