Mobile Communication

Exercise Sheet # 1

Cuneyt Erem, Baidar, Gular Shukurova

May 5, 2020

Exercise 1: Free Space and Two-Ray Ground propagation

The Free Space Propagation Model (FSP) and the Two-Ray Ground Propagation Model (TRG):

$$FSP : P_r = \frac{P_t \cdot \lambda^2}{d^2 \cdot (4\pi)^2} \quad (1)$$

$$TRG : P_r = \frac{P_t \cdot h_t^2 \cdot h_r^2}{d^4} \quad (2)$$

1. Path loss:

$$PL[db] = 10 \cdot log_{10} \frac{P_t}{P_r}$$

$$PL_{FSP} = 10 \cdot log_{10} \frac{P_t}{P_r} = 10 \cdot log_{10} \frac{P_t \cdot d^2 \cdot (4\pi)^2}{P_t \cdot \lambda^2} = 10 \cdot log_{10} \frac{d^2 \cdot (4\pi)^2}{\lambda^2}$$

$$PL_{TRG} = 10 \cdot log_{10} \frac{P_t}{P_r} = 10 \cdot log_{10} \frac{P_t \cdot d^4}{P_t \cdot h_t^2 \cdot h_r^2} = 10 \cdot log_{10} \frac{d^4}{h_t^2 \cdot h_r^2}$$

2. TRG does not provide meaningful results for small distances. Therefore it is a common practice to define a *crossover distance* d_c and use FSP for distances $d \leq d_c$, TRG for $d > d_c$. For this exercise sheet, we assume:

$$d_c = \frac{4\pi \cdot h_t \cdot h_r}{\lambda} \quad (3)$$

Prove that there is a smooth transition between the two models at the crossover distance, i.e. prove that both models yield equal results at d_c.

Proof:

We need to prove that $P_r(FSP) = P_r(TRG)$ when $d = d_c$. From equation (3) we can write λ as:

$$\lambda = \frac{4\pi \cdot h_t \cdot h_r}{d_c}$$

Then replacing the value of λin equation (1):

$$P_r(FSP) = \frac{P_t \cdot \lambda^2}{d^2 \cdot (4\pi)^2} = \frac{P_t \cdot (4\pi \cdot h_t \cdot h_r)^2}{d^2 \cdot (4\pi)^2 \cdot d_c^2} = \frac{P_t \cdot h_t^2 \cdot h_r^2}{d^2 \cdot d_c^2} = \frac{P_t \cdot h_t^2 \cdot h_r^2}{d^4} = P_r(TRG)$$