King Fahd University of Petroleum and Minerals
Department of Electrical Engineering

EE577 Wireless and Personal Communications

Homework Assignment #1 Due Date: March 18, 2006

Problem 1: (Assigned to 201705, 250153, 250567)

The received power at a distance of 1 Km is equal to 1μW, find the received powers at a distance of 3km, 7 km, 15 km and 20 km from the same transmitter the following path loss models:

(a) free space,
(b) $\alpha = 3$,
(c) $\alpha = 4.5$,
(d) two ray plane earth model,
(e) extended Hata Model.

The other link parameters are, f = 1900 MHz, h_t=40m, h_m = 3.5m, $G_t = G_r$ = 0 dB.

Problem 2: (Assigned to 213415, 250317, 250545)

(a) An improvement in the propagation coverage can be obtained by raising the base station antenna height. On the assumption that the received signal at a certain location is -112 dBm when the base station antenna height is 80m, to what height the base station antenna must be raised in order to increase the signal strength at that location by 7 dB?

(b) If the propagation path loss varies as d^{-4}, what percentage increase in coverage distance is possible if the receiver is made 5 dB more sensitive?

Problem 3: (Assigned to 240128, 250321, 250567)

In certain measurements over a quasi-smooth terrain, the 1 km intercept was measured to be -67 dBm. It was determined that over a distance of 10 km, the signal attenuates at a rate of 39.8 dB per decade increase in distance. The measurements were conducted with a base station having the following parameters: Base station Power 10W, Antenna height 50m, Antenna Gain G_t 6 dB, Mobile antenna height 3m, Mobile antenna gain 0 dB. If the base station parameters are modified to allow for greater range, find the distance beyond which the signal power falls below -112 dBm. The new parameters are: Base station Power 40 W, Antenna gain 8 dB, height 60 m, Mobile antenna height 3m, Mobile antenna gain 1.5 dB. Frequency of operation for both cases is 935 MHz.

Problem 4: (Assigned to 240356, 250317, 250543, 974073)

A tour company operates a river excursion boat and wants to install a mobile link with a base station located on the roof of a building 60 meter high. The building is located at a distance of 7 km from the north river bank. The initial experiments with the link proved successful at all times except when the boat goes behind a high rise building located 3 km from the north bank. The obstructing building is 93 m tall.

(a) Find total propagation loss between the base and the mobile when:

(i) the mobile is at midstream,

(ii) the mobile is at the south bank if the river is 1 km wide.

(b) The height of boat's mobile antenna is 6m, and the frequency of transmission is 840 MHz. If the intervening land is quasi-smooth and contains urban construction, determine the total propagation loss when the boat goes behind the high rise building.

Problem 5: (Assigned to 250153, 250545, 974073)

A consultant is hired by a taxi dispatch operator to design a mobile link in a large city. The operator has a licence to operate radio equipment at 463 MHz with a power of 100 Watts. He can install the base station antenna on a building at a height of 80m. The topography of the area surrounding the base is shown in Figure P-2.7. Find the signal power at the airport 40 km from the base station. The intervening terrain is made up of urban terrain (α =3.9) for the first six km and suburban terrain (α =3.4) for the remainder of 34 km. The propagation loss varies as $d^{-\alpha}$.

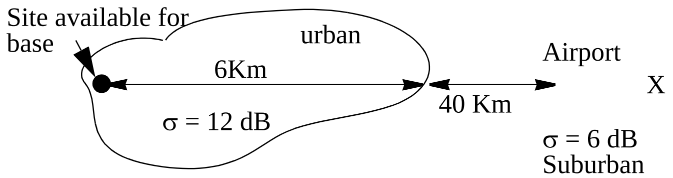

Figure P-2.7 Basestation location relative to the airport

Problem 6: (Assigned to 240356, 250317, 250567)

For the link shown in Figure P-2.8, it is required to measure the signal strength when the mobile unit is moved towards the transmitter starting from a location 12 km away. The signal received at the mobile at a distance of 15 km is measured to be -98dBm, and the intervening terrain is such that the signal attenuates 12.4 dB for every doubling of the distance. Draw a graph showing variation of signal strength with distance.

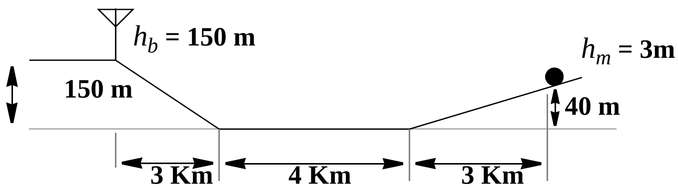

Figure P-2.8 Base station and mobile locations for Problem P-2.8

Problem 7: (Assigned to 240128, 250321, 250543)

A receiver in an urban cellular radio system detects a 1mW signal at $d = d_o = 1$ meter from the transmitter. In order to mitigate co-channel interference effects, it is required that the signal received at any base station receiver from another base station operating at the same frequency must be below -100 dBm. A measurement has determined that the average path loss exponent in the system is 3. Assume the system operates at a frequency of 1800 MHz.

Problem 8: (Assigned to 213415, 250543, 250545)

(a) A 150 m high base station serves a downtown core where the mean signal strength is log normally distributed with a standard deviation of 11 dB. The mean signal strength at a distance of 1 km from the base station is measured to be -57.8 dBm, and the signal attenuates at a rate of 41.3 dB per decade increase in distance. Estimate what fraction of locations will receive adequate signal strength (-102 dBm) at a distance of 23 km.

(b) Find the radius of the circle within which 90% of the locations have adequate signal strength.

Problem 9: (Assigned to 201705, 250321, 250545)

A transmitter provides 10W to an antenna with 6 dB gain. The 200 kHz bandwidth receiver is connected to an antenna having a gain of 2 dB. If the receiver noise figure is 4 dB and the carrier frequency is 920 MHz, determine the maximum transmitter-receiver separation that will ensure a SNR of 25 dB for 95% of the time. Assume propagation loss varies as 37 dB/decade beyond a distance of 1 km. Free space loss may be considered to be applicable up to a distance of 1 km.

Problem 10: (Assigned to 201705, 250567)

(a) A medium size ancient city is said to have been built on a quasi-smooth terrain sloping at an angle of 2^o as shown in Figure P-2.14. A 35m long base station antenna is installed on a 100m high ridge as shown. The mobile antenna is 1.5m high. The transmitter power is measured to be +50 dBm. Use Hata's empirical formula and Okumura's correction factors to find the signal strength a the location marked •. The frequency of operation is 850 MHz. Assume antenna gains to be unity.

(b) If the receiver at the location has a noise figure of 4.5 dB and the receiver is attached to a 3m antenna. Find the signal to noise ratio when the receiver bandwidth is 1.25 MHz.

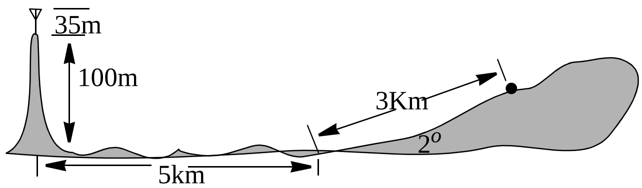

Figure P-2.14 The geometry of medium sized city built on a quasi-smooth sloping terrain

Problem 11: (Assigned to 213415, 250153, 974073)

In a 1800 MHz cellular system, the base transmitter is transmitting an EIRP of 150W using a 0 dB gain antenna. The receiver having a bandwidth of 30 kHz has a noise figure of 8 dB. A SNR at the receiver is desired to be 24 dB. The terrain intervening the transmitter and the receiver is flat with some built up areas, which causes shadowing of standard deviation of 6 dB. Determine the percentage of the time that the desired signal is available at a distance of 6 km.

Problem 12: (Assigned to 201705, 240356, 250317)

Explain what is fade margin and why it is required in the link analysis of wireless communication systems. Also, discuss what happens if the fade margin is not set appropriate level.

A transmitter delivers 10W to a 10dB gain antenna. The receiver antenna having a gain of 2.5 dB is connected to a receiver of bandwidth 200 kHz. The receiver has a noise figure of 8 dB, the carrier frequency is 900 MHz and the antenna temperature is 18^oC. Determine the maximum T-R separation that will ensure that a SNR of 18 dB is provided for 95% of the time. Assume propagation constant of 4, σ = 8dB and d_o = 1km.

Problem 13: (Assigned to 213415, 250321, 250543)

Calculate the maximum permissible path loss P_{Lmax} for the following link.
Transmitter power = 30 dBm
Transmit antenna gain = 6 dB
Receiver antenna gain = 1.25 dB
Line losses in the transmitter system = 1 dB
Line losses in the receiver system = 1 dB
Fade Margin = 15 dB
Noise power spectral density = -170 dBm/Hz
Bit rate 384 kbits/sec
Required E_b/N_o = 27 dB.

Problem 14: (Assigned to 240128, 974073)

(a) Find the transmitter power from a portable terminal operating at 1678 MHz to deliver E_b/N_o of 6 dB at one of Irridium satellite happens to be at a height of 770 Km above ground. The noise figure of the satellite receiver is 2.5 dB. The transmitted signal occupies a bandwidth of 10 MHz.

(b) If the terrain in which the mobile is operating results in shadows with a standard deviation of 4 dB. Find the probability of signal outage i.e. Prob (E_b/N_o < 6 dB).

Problem 15: (Assigned to 240356, 250153)

Determine the missing items in the following satellite up-link budget.

Earth station EIRP	110 dBW
Additional up-link atmospheric losses	0.8 dB
Free space path loss	205 dB
Carrier power at satellite	???
Satellite line losses	1.2 dB
Satellite G/T_e	-6dBK-1
Satellite C/T_e	????
Satellite C/N_o	????
Satellite E_b/N_o	????
Satellite C/N	????
Bit rate	128 Mbits/sec
Modulation	8PSK (3 bits/symbol)