

Question 1

You are asked to determine the signal-to-interference ratio (S/I or SIR), also known as the carrier-to-interference ratio (C/I , CIR), on the forward link (from base to mobile) of a cellular system, when the mobile is located on the fringe of its serving cell. Assume that all the cells have equal radii, and that the base stations have equal power and are located in the centers of each cell. Also assume that each base station transmits an independent signal such that the interfering signal powers may be added. Let us define a tier of cells as the collection of co-channel cells that are more or less the same distance away from the mobile in the serving cell. You wish to explore the impact of the cluster size, the number of tiers used in the calculations of C/I and the impact of the propagation law exponent on the value of C/I .

- a) What is the average distance, between the mobile on the fringe of the serving cell and the first tier of co-channel cells?. How many cells are located in the first tier? Solve for the cases of $N = 1, 3, 4, 7$ and 12 cluster sizes. How does the average value compare to the value of $D = QR$ where $Q = \sqrt{3N}$?
- b) What is the average distance between a mobile on the fringe of the serving cell, and the second and third tier of co-channel cells, and how many channels are in the second and third tiers of co-channel cells in the cases of $N = 1, 3, 4, 7$ and 12 cluster sizes?
- c) Determine the forward link C/I for the following frequency re-use designs: $N = 1, 3, 4, 7$ and 12. Assume that the propagation path loss exponent is four, and compute the S/I contribution due to just the first tier and then due to additional outer tiers of co-channel cells. Indicate the number of tiers at which there is a diminishing contribution to the interference at the mobile.
- d) Repeat part c) except now consider a line-of-sight path loss exponent of $n = 2$. Notice the impact the propagation path loss exponent has on C/I . What can you say about the path-loss exponent, the cluster size and the resulting C/I values? How would this impact practical wireless system design?

Question 2

a) In a two ray ground reflection model θ_{Δ} is the phase difference between the two main signals arriving at the receiver: the direct path, and the ground-reflection path. Assume that θ_{Δ} must be kept below 6.261 radians for phase cancelation reasons. Assuming a receiver height of 2 m, and given a requirement that the angle of incidence θ_i be less than 5° , what are the minimum allowable values for the T-R separation distance and the height of the transmitter antenna? The carrier frequency is 900 MHz.

b) Compare the received power for the exact (equun 4.47, text) and approximate (equun 4.52, text) expressions for the two ray ground reflection model. Assume the height of the transmitter is 40 m and the height of the receiver is 3 m. The operating frequency is assumed 1800 MHz, and unity gain antennas are being used. Plot the received power for both models continuously over the range 1 km to 20 km. Assume the ground reflection coefficient is -1 for horizontal polarization.

Question 3

Assume a receiver is located 10 km away from a 50 W transmitter. The carrier frequency is 1900 MHz, free space propagation is assumed, $G_t = 1$ and $G_r = 2$. Find:

a) The power at the receiver

b) The magnitude of the E at the receiving antenna.

c) The open circuit *rms* voltage applied to the receiver input assuming the receiving antenna has a purely resistive impedance of 50Ω 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 the transmitting antenna is 50 m, receiving antenna 1.5 m above the ground and the ground reflection coefficient is -1 .

Question 4

A direct communications channel is to be established between town A and town B on the other side of a mountain as depicted on the Figure 1 below. The figure shows the relative locations of the two towns relative to the obstruction, and their relative elevations. The communications frequency is assumed 400 MHz. For analysis purposes, the mountain may be treated as a single knife-edge.

a) Using a knife-edge diffraction model, determine h , the excess height above line of sight, and α , the pitch angle.

b) Determine the excess path length Δ .

- c) The peak of the mountain comes closest to which Fresnel ellipsoid?
- d) Evaluate the Fresnel-Kirchoff diffraction parameter v .
- e) What is the approximate knife-edge diffraction gain in dB ?
- f) Is it possible to achieve half-power transmission (compared to the obstacle free case) by adjusting the transmission frequency? Explain.

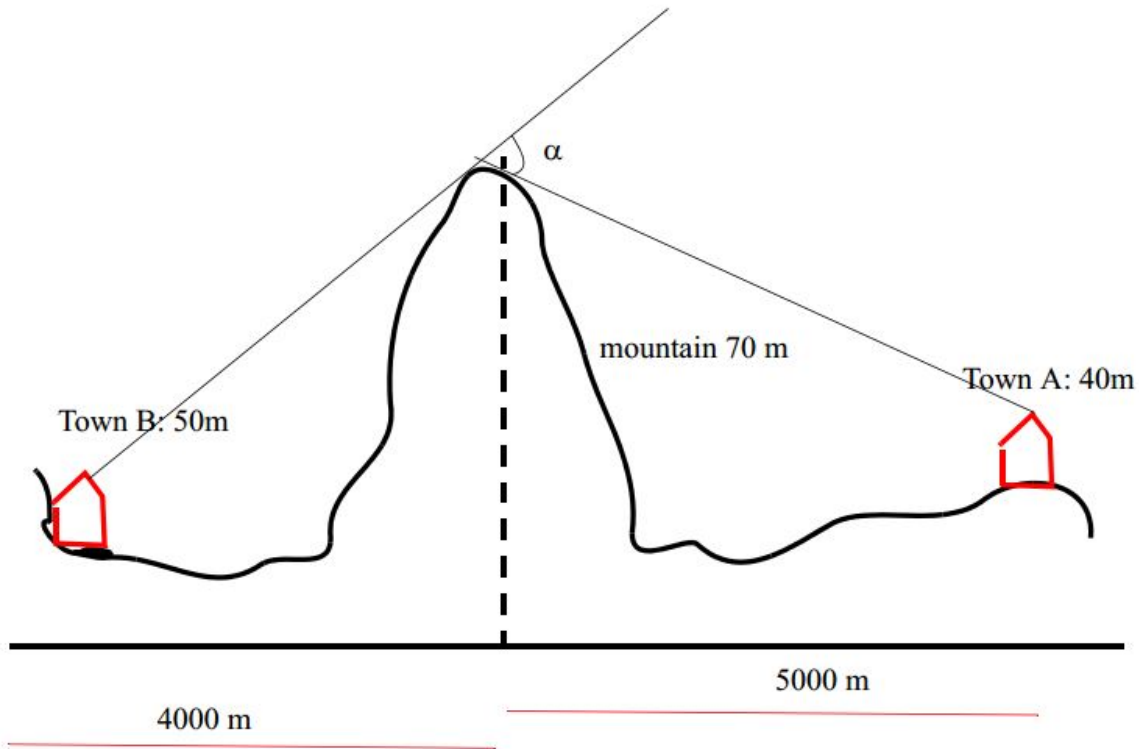


Figure 1: Knife Edge

Question 5

Consider the two-state model of the Rayleigh fading channel described in the course notes. Consider a mobile receiver moving at a constant speed such that the maximum Doppler frequency shift is 20 Hz, and the minimum acceptable received level is 20 dB below the *RMS* level.

- a) Determine the average fade duration τ_f .
- b) If we transmit data at a rate of 10,000 bits/sec., what is the average length (in bits) of an error burst?
- c) Use the two state model to determine the average Bit Error Rate (BER).