Department of Electrical Engineering, IIT Madras

EE5141: Intro to Wireless and Cellular Communications

Tutorial #2 **March 2026**

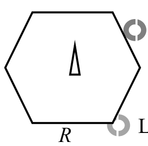
1. A frequency selective channel model is characterized by a 3-tap magnitude-delay profile given as follows: the tap magnitudes are $\{0.6, \alpha, \beta\}$ with delays {0, 1μs, 3μs}, respectively. Choose α and β such that $0.6^2 + \alpha^2 + \beta^2 = 1$, i.e., the channel gain is unity.

(a) Express the rms delay spread, σ_τ, in terms of α and β.

(b) For what choice of α (and β) would σ_τ be maximum (even while satisfying the unity gain constraint)? What are these value(s) for α, β and the corresponding σ_τ ?

2. Two different TDMA systems use the same transmit power, antenna gains, and modulation. Further, assume that both these systems have the same overall noise-figure, and the free-space path loss exponent *n*=3. System #1 uses a carrier frequency that is 6 times lower than that of system #2 and also has a signal bandwidth that is 10 times lower than that of system #2. Let the maximum link distance for system #1 and system #2 be denoted by d_1 and d_2, respectively. What then is the ratio d_1/d_2 ?

3. A reuse-1/4 (4-cell reuse) TDMA+FDMA cellular system uses omni base-stations at the middle of each (hexagonal) cell with side *R* meters. Evaluate the downlink signal to interference (SIR) ratio expression, <u>assuming only the first tier of interfering base-stations</u>, for the following 2 locations of the user:



Location #a: At the apex of the hexagon
Location #b: At the middle of a side of the hexagon
Assume no noise.

(a) Find worst-case SIR expression at Location #a and Location #b, assuming path-loss exponent *n*=4.

(b) By how many dBs (in the decibel scale) is the SIR at location #a better (or lower) than the SIR at location #b?

4. Consider a 5MHz DS-CDMA system with spreading factor $T/T_C = W = 512$. Assuming perfect Up-Link (UL) power-control, and the aim is to compute the uplink soft-capacity, sum-rate, and power set-point for three different link data-rates. Assume that the thermal noise power spectral density at the DS-CDMA base-station receiver is -174dBm. The path-loss exponent is *n*=2.5, and the carrier frequency f_C =3GHz. The mobile station (MS) with a Tx power of P_T=10dBm uses an omni antenna with gain 0dBi while the base station (BS) uses a panel Rx antenna with gain 12dBi. It is also given that the Rx noise figure is 3.5dB, and the required post-processing SINR = 4.5dB for the considered modulation. Denote the BS receiver noise variance as σ^2, and the Rx power on each link (per bit) as P. Now answer the below questions:

(a) What is the uplink pole capacity N_P of this system? If all users arrive at rate R bits/sec (where R = 1/T where T is the symbol duration) and with same power P, what is the maximum UL sum-rate in bits/sec?

(b) For an allowed noise rise of 12dB:

(b1) find the number of users N who can be supported at rate R bits/sec. What is the UL sum-rate?

(b2) find the radius of the cell (in km) for this noise rise

(c) For this 12dB noise rise in Q.(b), and for the *same* sum-rate, users are assigned one of the 3 rates, namely, R : R/ 2: R/4 in the ratio 1:3:8. What are the <u>total number of users</u> connected on the uplink now?

(d) In Q.(c), how many (integer number of) users would be there in each of the 3 rates? If you want to have *exactly* the same sum-rate as in Q.(b), but with the *least change* to the given ratio, how many users would you allow in each of the 3 rates? Explain your logic.

(e) For your answer in Q.(d), what is the value of ratio P(R)/P(R/4), where P(X) is the set-point for the UL received power for rate X? Comment on your answer.