Assignment #3

Due: Oct. 11, Wed. 8:30, SMD 224 (beginning of the tutorial). Hard copy only, no email submissions. *Late entries will not be accepted!*

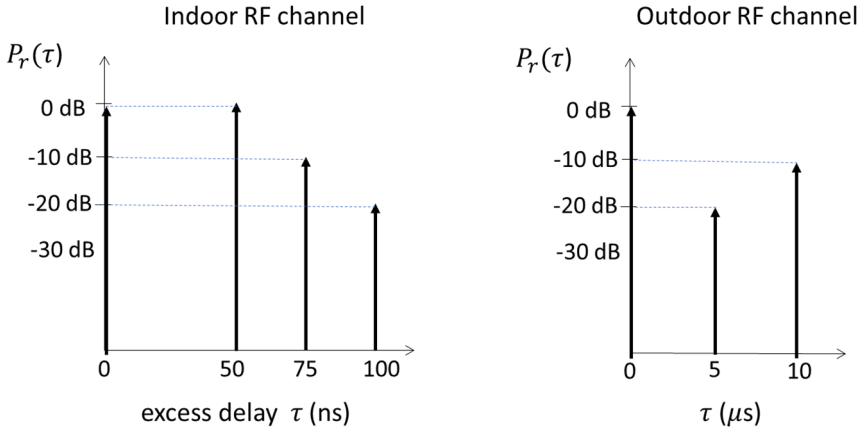
Before doing the assignment, please read appropriate sections of Chapter 4 and 5 of the course textbook (by Rappaport, 2nd edition (2002)) or any other relevant book (e.g. from the reference list).

1) Assume that a SNR of 25dB is desired at the receiver. If a 900 MHz transmitter has an EIRP of 100W, and the receiver uses a 0 dB gain antenna and has a 10 dB noise figure, find the percentage of time that the desired SNR is achieved at a distance of 10 km from the transmitter. Assume that the path loss exponent $\nu = 4$, and d_0= 1 km, $P_r(d_0) = -39$ dBm. This also includes log-normal shadowing (see section 4.9.2 of the textbook) of standard deviation σ=8 dB. What is the outage probability?

2) There are 200 students in a classroom, each one with a modern WiFi device supporting wireless Internet connection. The average SNR in the room is $\gamma_0 = 10$ dB and the threshold SNR (for reliable link connection) is $\gamma_{th} = 10$ dB. Assuming that each link experiences independent and identically distributed (i.i.d.) Rayleigh fading,

- how many students on average will not be able to connect?
- How your answer would change if $\gamma_0 = 20$ dB?
- What if fading is Ricean with $K = 0$ dB and $\gamma_{th} = 10$ dB, $\gamma_0 = 20$ dB?
- How does this change if K increases to 10 dB?
- Compare all your answers and make recommendations for a contractor installing a WiFi access point.

3) (A) Given that the coherence bandwidth is approximated by $\Delta f_c \approx 1/(5\Delta\tau)$, show that a flat fading channel occurs when $T_s \geq 10\Delta\tau$. Hint: note that Δf_c is an RF bandwidth, and assume that T_s is the reciprocal of the baseband signal bandwidth. (B) If a particular modulation provides suitable BER performance whenever $\Delta\tau / T_s \leq 0.1$, determine the smallest symbol period T_s (and thus the greatest symbol rate) that may be sent through the 2 RF channels (without using an equalizer) whose measured impulse responses are shown in the figure below (normalized to the peak value).



4) If a baseband binary message with a bit rate R_b= 100 Mb/s is modulated by an RF carrier using BPSK, answer the following:
   a) Find the range of values required for the rms delay spread of the channel such that the received signal is flat-fading signal.
   b) If the modulation carrier frequency is 5.8 GHz, what is the coherence time of the channel, assuming a vehicle speed of 30 km/h ?
   c) For your answer in (b), is the channel "fast" or "slow" fading?
   d) Given your answer in (b), how many bits are sent while the channel appears "static"?

5) For each of the three scenarios below, decide if the channel is slow or fast fading, and flat or frequency selective fading. Assume that the channel is between a cellular base station and a user cell phone.
   (a) A binary modulation has a data rate of 5 Mb/s, f_c= 1 GHz and a typical urban radio channel is used to provide communications to cars moving on a highway.
   (b) A binary modulation has a data rate of 5 kb/s, f_c= 1 GHz and a typical urban radio channel is used to provide communications to cars moving on a highway.
   (c) A QPSK modulation has a data rate of 10 Mb/s, f_c= 1 GHz and a typical urban radio channel is used to provide communications to cars moving on a city street.

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Please include in your solutions all the intermediate results and their numerical values (if applicable). **Detailed solutions with explanations are required**, not just the final answers/equations; **all symbols used must be defined**, including units used (e.g. f = frequency [Hz], L = path loss [dB]). Missing explanations, symbol definitions/units will be penalized. Your answers should demonstrate the full extent of your knowledge and the latter will determine your marks.

Plagiarism (i.e. "cut-and-paste" from a student to a student, other forms of "borrowing" the material for the assignment) is absolutely unacceptable and will be penalized. Each student is expected to submit his own solutions. If two (or more) identical or almost identical sets of solutions are found, each student involved receives 0 (zero) for that particular assignment. If this happens twice, the students involved receive 0 (zero) for the entire assignment component of the course in the marking scheme and the case will be send to the Dean's office for further investigation.