Assignment #5

Due: Nov. 29, 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 6 of the course textbook (by Rappaport, 2nd edition) or any other relevant book (e.g. from the reference list).

1) On the same graph, plot the probabilities of bit error as functions of the average SNR per bit [dB] in the AWGN channel for BPSK, DPSK, QPSK, 16-QAM and 64-QAM. Use SNR range of 0 to 15 dB. Compare them and explain the difference, if any. What are the advantages and disadvantages of these modulation formats from a wireless communication viewpoint? List some possible applications of these modulation formats.

2) A wireless internet access card requires for reliable operation the BER not exceeding 10^{-3}. An engineer designing this card wishes to maximize the data rate over the SNR range of 0 to 20 dB. Select a proper modulation format for each SNR at this range. Hint: M-ary constellation, such as M-QAM is a good candidate, with $M = 2^l$, $l = 2,3,4...$, for which you have to find a threshold SNR $\gamma_{th}(M)$ such that $P_e(\text{SNR},M) \le 10^{-3}$ if $\text{SNR} \ge \gamma_{th}(M)$, where $P_e(\text{SNR},M)$ is the BER as a function of SNR and constellation size M, and threshold SNR $\gamma_{th}(M)$ is a function of constellation size as well. Having done this, for each value of the SNR the engineer will use such constellation size M that (i) maximizes the date rate, and (ii) respects the BER constraint $P_e(\text{SNR},M) \le 10^{-3}$. Such a scheme is called adaptive modulation (signal constellation size is adjusted according to the SNR). Find and plot the resulting data rate of this adaptive modulation and the maximum achievable data rate versus the SNR if the channel delay spread is 10 ns. Comment on the difference between the two and propose a way to bridge the gap. Additionally, plot the BER of this adaptive modulation versus the SNR and sketch a block diagram of a modulator and demodulator for this adaptive system.

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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.