Exam 1
due 03/29/06

Discrete Multitone System Design

In this problem you will get to investigate the system design space for a discrete multitone system. System parameters are the number of tones (i.e. points in the FFT) and the sampling rate.
Assume the channel is a single-pole channel with 1MHz bandwidth.
Assume that average transmit power is fixed to 1µW and thermal noise power is Pnoise=-174+10*$\log_{10}$(Δf)+NF_dB [dBm], where Δf=1/Tsamp (dBm is a measure relative to 1mW) and NF_dB=20 [dB] is the noise figure of the transceiver electronics.
Assume that target BER is 10^{-6}.

1) (15pts) Plot the capacity of this channel as a function of the sampling rate, using the waterfilling code from problem set 1. (Hint: Since average power is fixed, make sure you adjust the energy as you change the sampling rate, and also use a large enough number of tones to reach the stable capacity values). Plot the capacity as a function of sampling rate. What happens to the capacity as the sampling rate increases beyond the waterfilling bandwidth?
2) (5pts) Using Gap approximation for BER of 10^{-6}, estimate the uncoded discrete multitone performance for QAM, without discrete loading. (Hint: Use the same waterfilling script). Again, plot the data rate vs. the sampling rate.
3) (40pts) Implement the rate adaptive (RA) Levin-Campello loading algorithm, assuming all tones are loaded with QAM modulation and using the Gap approximation.
4) (20pts) Assuming that the channel length can be approximated by the length of the pulse response within the pulse energy represent the 99% of the total pulse energy, find the cyclic prefix as a function of sampling rate, and use this to plot the data rate of the system, as a function of sampling rate and number of tones used.
5) (20pts) Using the setup from 1) and 2) investigate the behavior of the data rate as a function of the sampling rate and number of tones used. What is the maximum data rate you can achieve on this channel, with given system settings? What happens if you choose too high a sampling rate?

Please turn in the writeup with plots and comments, and all the code that you have written for this exam. The code must be clean of bugs and able to run to confirm the plots that you turned in.