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ECSE413B: COMMUNICATIONS SYSTEMS II

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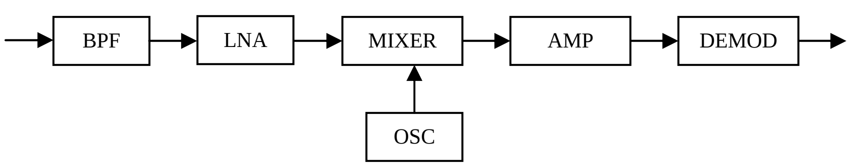
Assignment 2: Transmission Techniques, due date: Thursday, March 6/2008

1. Using the equations for the (exact) probability of symbol error of the M-ary ASK (or PAM), PSK, QAM and orthogonal FSK, plot the "probability of symbol error versus E_b/N_o" curves for the range (of probability of symbol error) from 10^{-3} to 10^{-8}, and compare their performance for M=16, and 64. Note that E_b is the average *bit* energy and $E_b\log_2 M=E_s$ (see C1).

2. For the same probability of symbol error (e.g., 10^{-6}), derive and plot "the required E_b/N_o versus M" for M-ary ASK (or PAM), PSK, QAM and orthogonal FSK and M=4, 8, 16, 32, 64,128, 256. Compare and discuss the results (see C1).

3. You are requested to design a point-to-point communications link to support a transmission rate of 12Mb/s using a carrier frequency of 2.17GHz.
   (a) Determine the allowable bandwidth at the carrier frequency of 2.17GHz (See B1 page 30). From the allowable bandwidth and transmission rate, calculate the required bandwidth efficiency in b/s/Hz.
   (b) Select an M-ary PSK or M-ary QAM scheme (using root raised-cosine filters in both transmitter and receiver) and the roll-off factor of the detection filter to meet the requirements and FCC mask. Justify your selection and sketch the Tx spectrum with FCC mask (See B1 pages 30-32 and C2).
   (c) Consider a threshold BER of 10^{-4} over a link 20km with a link availability of 99.999% in a maritime temperate, average terrain US region (K=4/3). For a receiver with an overall noise figure of 6dB, a typical cable loss of 3dB per site, and a performance degradation of 1.5dB due to practical implementation, calculate the required fade margin, Tx power, and Tx and Rx antenna gain (See B1, C1).
   (d) For 6dB improvement, calculate the required vertical separation in space diversity, and the required frequency separation in frequency diversity (See C3, pp.21-22).
   (e) Repeat the problem with
      (i) a transmission rate of 120Mb/s using a carrier frequency of 11GHz, and
      (ii) a transmission rate of 60Mb/s using a carrier frequency of 3.8GHz.

4. Figure 1 shows a block diagram of a receiver



BPF: RF bandpass filter with insertion loss L_{BPF}=1.5 dB
LNA: Low-Noise Amplifier with gain G_{LNA} and noise figure NF_{LNA}
MIXER: passive mixer including bandpass filter with conversion loss L_{MIXER}=8dB
AMP: IF amplifier with gain G_{AMP} and noise figure NF_{AMP}=6dB
DEMOD: A demodulator with a noise figure of 8dB

Figure 1: A Receiver Structure

(a) Select the values for G_{LNA}, NF_{LNA}, and G_{AMP} to achieve the overall noise figure of 6dB or better (lower)

(b) For a received signal power of –90dBm and a noise power spectral density of –174dBm/Hz at the receiver input, calculate the available E_b/N_o at the input of the demodulator if the transmission rate is 5Mb/s

5. Consider a BPSK transmission using coherent demodulation.

(a) What is the required E_b/N_o to achieve a bit error probability, P_b, of 10^{-4} in an AWGN channel.

(b) For the E_b/N_o obtained in (a), calculate the bit error probability of the BPSK system using L-path MRC diversity in a Rayleigh fading channel with $\sigma^2=1$ when L=2,3,4,…,10

(c) Repeat (b) with $\sigma^2=0.5$ and with $\sigma^2=2$. Compare the results obtained in (a)-(c) and discuss the effects of L and σ^2 on the system performance.