ESE 471 Spring 2021: Homework 8

1. (20 points) In Lecture 16 on bandwidth efficiency, we did not calculate the bandwidth efficiency for coherent FSK. Assume that $\Delta f = \frac{1}{2T_s}$ and that the pulse shaping is SRRC with shape parameter α.

   (a) Derive an expression for the bandwidth efficiency η for M-ary coherent FSK, as a function of M and α.

   (b) Create a table (similar to Table 2 in the Lecture 16 notes) that gives the value of η for M-ary coherent FSK for $\alpha \in \{0, 0.5, 1\}$ and $M \in \{2, 4, 8, 16\}$.

2. (30 points) A $M = 16$ square QAM communication system operates at a center frequency of 800 MHz and has a symbol rate of 1.25 MSymbols/sec. Assume the system uses SRRC pulse shaping with an $\alpha = 0.25$. The system must achieve a required probability of bit error of 6×10^{-5}.

   (a) Calculate the minimum C/N_0 ratio to achieve the required probability of error.

   (b) Although we didn't cover this in class, the signal-to-noise ratio (SNR) is defined as the power ratio, C/N, where $N = N_0 B$, where B is the bandwidth of the signal. Calculate the minimum required SNR in dB from your answer to (a).

   (c) Find the range of this system. Assume the transmit power $P_T = 0.01$ W (that is, 10 mW), the antenna gains are $G_T(\text{dB}) = G_R(\text{dB}) = 2$ dB, and that the receiver has a $T_{eq} = 1200$ K. Assume the path loss exponent model for received power with $n_p = 3.0$ and reference distance $R_0 = 1$ m. Caution: Don't mistake linear units and dB – know which you are given and which you need to use.

3. (10 points) A receiver has a received power of -121.5 dBW. The noise figure F of the receiver is 8 dB, and you may assume a noise temperature of $T_0 = 290K$. Note that $T_{eq} = FT_0$. The modulation is binary FSK at a bit rate $R_b = 1.5$ Mbps, and the receiver is a non-coherent receiver. What is the probability of bit error?