XMUT310 Communications Engineering

Homework 3 (7.5%)

Show you working clearly; submit a single PDF file. Write your name in English and your student ID clearly.

Question 1 [25 marks; 10 marks each for a,b and 5 for c]

Digital PAM data are to be transmitted using rectangular pulses and antipodal signalling (1 and 0 represented by positive and negative pulses, respectively) over a baseband system with $N_0 = 10^{-7}$ W/Hz and the received signal amplitude $A = 20$ mV.

a) If 10^3 bps are transmitted, what is the probability of error P_e?
b) If 10^4 bps are transmitted, to what value must A be adjusted in order to attain the same P_e as in (a)?

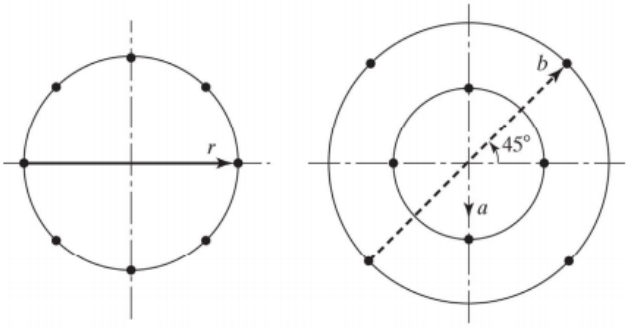
c) What conclusion can you observe from the above calculations?

Note: you may use the approximation

$$Q(u) \approx \frac{e^{-u^2/2}}{u\sqrt{2\pi}} \quad u >> 1$$

Question 2 [30 marks; 10 marks each for a,b,c]

Consider the 8-point QAM signal constellation shown below



8-PSK 8-QAM

a) Determine the symbol rate if the desired bit rate is 90 Mbps
b) Compare the SNR required for the 8-point QAM modulation with that required for an 8-point PSK modulation having the same error probability. You may assume that the error probability is dominated by the argument of the Q-function
c) Which signal constellation is more immune to phase errors? Why?

Question 3 [15 marks; 10 for a; 5 for b]

a) A binary PCM system with NRZ signaling and *rectangular pulses* operates with BER of 10^{-5}. Suppose the signaling rate is doubled. Find the new value of the average probability of error. Use the table of $Q(x)$ provided.

b) What conclusion can you observe from this calculation?

Question 4 [30 marks; 10 marks each for a,b,c]

Consider binary PAM with rectangular pulses of amplitude A operating over an AWGN with $N_0 = 10^{-7}$ W/Hz). Suppose that the available channel bandwidth is 5 kHz.

a) What is the maximum data rate that can be supported by the channel?
b) If E_b/N_0 is 10.53 dB, what is the signal amplitude A?
c) What is the probability of error?

Note: Assume a rectangular pulse shape

$$\text{rect}(t/T) \leftrightharpoons T\,\text{sinc}(fT)$$

and take the signal bandwidth to be that of the first null of the sinc function.

Question 5 [20 marks; 10 marks each for a,b]

Some switching circuits generate impulse noise, which can be modeled as filtered white noise with average power, σ^2, and an exponential distribution

$$p_n(n) = \frac{1}{\sqrt{2\sigma^2}} e^{-\sqrt{2}|n|/\sigma}$$

a) Derive the expression for P_e for a binary PSK system contaminated by such noise, as opposed to AWGN in (b). Once again, assume pulse amplitude A at sampling time and use symmetry to determine the decision thresholds. *Hint: remember, of course, that* $|\alpha| = -\alpha$ *for* $\alpha < 0$ *and* $|\alpha| = \alpha$ *for* $\alpha > 0$
b) Compare the two systems by determining the signal amplitude A (as a function of σ) required to achieve $P_e = 10^{-3}$. Which system requires more power?