

Digital Communications
Homework #7
Due 12/3/2007

1. Plot the probability of bit error error vs. E_b/N_o (in dB) for M -PSK for $M = 2,4,8, 16$. How much loss (in dB) is there when for QPSK, 8-PSK and 16-PSK compared to BPSK at a bit error rate of 10^{-3} .

2. A receiver with a system noise figure of $F=5dB$ is being used to receive a microwave signal ($f=2GHz$). The transmit power is 10mW and the transmit and receive antennas are identical with 2dB of gain. If the modulation scheme is 8-PSK, what is the maximum data rate that can be achieved at a distance of 10km if a target BER of 10^{-5} is required? Note that matched filtering is assumed. Assume free space propagation. This is a point-to-point link, so ignore fading considerations. Don't consider bandwidth.

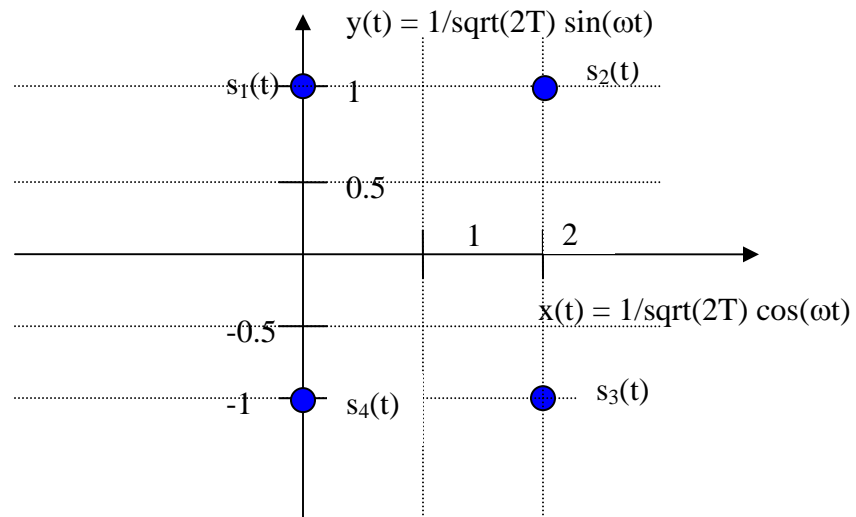
- 3 An engineer in your group has found a error correction coding chip that will provide your system with 3dB of gain at the target error rate. Using the same system as in (2) determine the data rate that is now supported. Don't consider bandwidth.

4. It turns out that this system will be used to transmit to systems throughout an entire county. Since there is log-normal shadowing due to the hilly terrain, it is determined that 10dB of fade margin is required to obtain 95% coverage. Assuming the same system as in (3) what data rate can be supported?

5. Which of the two systems listed below requires higher transmit power?

	<u>System A</u>	<u>System B</u>
Tx Antenna Gain	0 dB	0 dB
Tx Power	W	W
Path Loss	110 dB	110 dB
Data Rate	10 kbps	1 Mbps
Rx Antenna Gain	2.3 dB	2.3 dB
No	-195 dB W/Hz	-195 dB W/Hz
Modulation	8-PSK	QPSK
Error Rate Required	0.001	0.01
Fading Margin	10 dB	10 dB

6. Consider the following constellation diagram



(a) Derive the probability of bit error in terms of E_b/N_o assuming that all symbols are equally likely, that symbol errors are dominated by nearest neighbors, and that Gray coding is used.

(b) An analog message signal with uniform distribution and bandwidth 10kHz is to be digitized assuming Nyquist sampling and transmitted using the modulation scheme above. The receiver noise power spectral density is found to be $N_o = -200\text{dBW/Hz}$ and due to range considerations the maximum receive power is limited to $P_r = -135\text{dBW}$ (note that $E_b = P_r T_b$ where T_b is the bit duration in seconds). Using the expression derived above, determine the maximum quantization SNR when the probability of error is required to be equal to or below 10^{-3} .

7. Link Budgets

Consider a system which has a transmit power of 40mW, a transmit antenna gain of 5dB, a receive antenna gain of 8dB, a path loss of 90dB, a required fading margin of 5dB and the noise power spectral density is measured as -195dBW/Hz . The required error rate is 0.1%. Further, assume raised cosine pulse shaping with a roll-off factor of $a = 0.25$ and a matched filter receiver. The system bandwidth is limited to 500kHz. What is the maximum achievable data rate with this system? (You need only consider BPSK, QPSK, and 8-PSK modulation schemes).