

EECS 562
Homework 13

1. (Concepts: Noise performance of BPSK and required bandwidth) A BPSK system needs to transmit 20 Mbit/sec and provide a 10^{-5} BER. Let $N_0 = -97$ dBW/Hz. The path loss is 40.6dB.
 - a. Find the minimum required RF transmission bandwidth, BRF.
 - b. Find the required transmitter power in dB_W .

2. (Concepts: Noise performance of 8-PSK and required bandwidth) A 8-PSK system needs to transmit 30 Mbit/sec and provide a 10^{-5} BER. Let $N_0 = -97$ dBW/Hz. The path loss is 37.5dB.
 - a. Find the required RF transmission bandwidth in MHz, B_{RF} .
 - b. Find the required transmitter power in dB_W .

3. (Concepts: Comparison of BPSK and 16-QAM system performance) A BPSK system needs to provide the customer with a 2 Mb/s transmission rate with a performance specification of $\text{BER} = 10^{-6}$. $S_n(f) = N_0/2$ with $N_0 = 2.16 \times 10^{-17}$ W/Hz. The path loss between the transmitter and receiver is 108 dB.
 - a. Find the required transmit power in dB_W .
 - b. What is the benefit of switching the system to 16-QAM?
 - c. If the system uses 16-QAM with the BER fixed at 10^{-6} the transmit power needs to be increased or decreased compared to the power found in part a.

4. (Concept: Link budget for BPSK) A radio link has the following parameters:

Carrier frequency, f_c	1 GHz
Transmit power	2 W
Transmitter Antenna Gain	3 dB
Path loss	151.1 dB
Antenna temperature	290 K
Receiver antenna gain	17 dB
Receiver noise figure	6 dB
Information bit rate	1.5 Mb/s
BPSK modulation	

 - a. For BPSK the received signal is $A \cos(2 \pi f_c t)$ or $A \cos(2 \pi f_c t + \pi)$, find A.
 - b. Find the energy/bit = E_b .
 - c. What is the Bit Error Rate?

5. (Concept: Comparison of noise performance of digital modulation techniques) For a fixed $E_b/N_0 = 4$ dB, the BER for
 - a. QPSK
 - b. 8-PSK
 - c. 16-QAM
 - d. 64-QAM
 - e. 256-QAM
 - f. Why does the BER increase as the modulation changes from part a. to part e.

6. (Concept: Adaptive modulation - maintaining BER as signal strength decreases) Given a 8-PSK system operating at $f_c = 2.4$ GHz over a $d = 33.3$ km distance in an environment resulting in a path loss

of 130.5dB.

The receiver has a 6 dB noise figure and an antenna temperature of 100° .

The transmit and receive antennas are isotropic.

The customer requires a bit rate of 2.7Mb/s with a BER of 10^{-6} .

- a. What is the required $\frac{E_b}{N_0}$?
- b. What is N_0 in dB?
- c. What is E_b in dB?
- d. What is E_s in dB?
- e. What is the symbol rate r_s ?
- f. Find the receiver sensitivity in dB_W , that is, the received power, P_R , to achieve a BER= 10^{-6} .
- g. Find the required transmitter power in Watts and dB_W .
- h. With all the link parameters given above the receiver moves away from the transmitter. Find the distance (in km) such that the system has to switch to QPSK to maintain a BER= 10^{-6} ; switching to QPSK reduced its transmission rate to 1.8 Mb/s. Assume free space transmission.