S-72.227 Digital Communication Systems (Spring 2005)

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Diversity Techniques for Flat Fading Channels

1.

On a fading channel, the received average signal energy is measured to be 10^{-10} W. The fading in the channel is assumed to be Rayleigh distributed. The additive white Gaussian noise has a spectral density of $N_0/2 = 10^{-12}$ W/Hz. The receiver in use is assumed to work satisfactory if the SNR is larger than 4 dB.

a. Determine the time availability for the level 4 dB
b. We have the possibility of using diversity with selection combining. How many branches are required in order to obtain time availability of 99.99% ?

2.

Data transmission over a radio channel exposed to Rayleigh fading. The modulation method is binary coherent PSK and the mean SNR is 13 dB.

a. Determine the bit error probability for the transmission without diversity.
b. Determine the number of diversity branches required to obtain a bit error probability lower than 10^{-5}. The combining method is maximal ratio combining.
c. What is the bit error probability for a channel only disturbed by AWGN for the same SNR?

3.

In a two-branch diversity system with the modulation method noncoherent FSK, selection diversity combining is used. The radio channel is slowly flat Rayleigh fading and the signal envelope in each branch is regarded as uncorrelated with the same mean energy. Determine the reduction (expressed in dB) in mean SNR obtained for a bit error probability of 10^{-4}, if the combining method is changed to maximal ratio combining.

Spread Spectrum and CDMA

4.

A direct-sequence system has a PN code rate of 192×10^6 chips per second and a binary message bit rate at 7500 b/s.

a. If QPSK instead of biphase modulation, what is the processing gain?
b. Assuming that the received signal power is 4×10^{-14} watts and the one-sided noise spectral density level, N_0, is 1.6×10^{-20} W/Hz, find the signal-to-noise power ratio in the input of the receiver of the power.

5.

A total of 30 equal-power users are to share a common communication channel by CDMA. Each user transmits information at a rate of 10 kps via DS spread spectrum and a binary PSK. Determine the minimum chip rate to obtain a bit error probability of 10^{-5}. Additive noise at the receiver may be ignored in this computation.

6.

Given the following parameters of a spread spectrum communication systems:

$N_0 = 2 \times 10^{-15}$ W/Hz

J=Interference power = 5×10^{-7}

$P_r = 1.2 \times 10^{-8}$ watts

Equivalent receiver noise bandwidth = 50 MHz

a. Find the input SNR, $(SNR)_i$.

b. If the message bit rate is 10 kbps, find the output SNR, $(SNR)_o$.