Problem Set 2 (due Friday, February 2)

(The problem numbers for the exercises taken from the text are the same in both the editions.)

1. (10 points) Frequency-hopping spread spectrum

Problem 7.5.

2. (2 points) Maximum packet length in Bluetooth

In commercial wireless packet data networks using FHSS, such as Bluetooth, the chip duration are designed long enough to allow transmission of a full packet in each hop. The hopping rate of Bluetooth devises is 1600 hops/s. Assuming a data transmission rate of 1 Mb/s, what is the size of the largest packet that can be transmitted?

3. (8 points) Near-far problem in BPSK-DSSS

Two 100 mW BPSK DSSS mobile terminals with processing gains of 20 dB communicate with the same base station, using two different spreading codes. One of the mobiles communicates as an information source, and the other terminal acts as a source of wideband interference. Answer the following questions under the assumptions given below.

(a) Give the signal-to-interference ratio as a function of the distances between the two terminals and the base station.

(b) Plot the bit error rate versus the ratio of the distance of the target terminal and the interfering signal from the base station. At what relative distance ratio does the interfering terminal push the bit error rate below 0.01.

Path loss model: Assume that the distance power gradient (the exponent in the path loss equation) is 3.

Noise: Assume that there is no other background noise.

BPSK: Assume that the transmission bandwidth required for BPSK is twice the data rate and the Bit-Error-Rate (BER) is given by the following formula:

$$BER = \int_{\sqrt{2E_b/N_0}}^{\infty} \frac{1}{\sqrt{2\pi}} e^{-\frac{u^2}{2}} du.$$

(To calculate the above numerically, you can use the complement of the error function used in statistical analysis – e.g., the ERFC function in Excel.)

4. (6 points) Pseudo-random number generation

Problem 7.9.

5. (8 points) Error-correcting codes

An early code used in radio transmission involved codewords that consist of binary bits and contain the same number of 1s. Thus, the two-out-of-five code only transmits blocks of five bits in which two bits are 1 and the others 0.

(a) List the valid codewords.

(b) Suppose the code is used to transmit blocks of binary bits. How many bits can be transmitted per codeword?

(c) What pattern does the receiver check to detect errors?

(d) What is the minimum number of bit errors that cause a detection failure?

6. (10 points) Convolutional encoding

Problem 8.20.

7. (6 points) CRC

Prove that the CRC coding technique can detect any burst errors for which the length of the burst is less than or equal to the length of the frame check sequence (number of redundant bits), as long as the most significant and least significant bits of the CRC code are both 1.