

Mobile Communication Networks

Exercices 5

1. The CDMA system IS-95 speech encoder operates at a bit rate of 9.6 kbps, with a chip rate is 1.2288 Mchips/sec.
 - a. How many chips per bit are being used?
 - b. What is the spreading factor/gain?
 - c. What is the (approximate) ratio between the bandwidth of the spread signal and the bandwidth of the original signal?

2. Consider the two-sender CDMA example of the slides.
 - a. Draw the reception diagram for receiver 2.
 - b. Code 1 and Code 2 are orthogonal? Why?
 - c. How many chips per bit are being used?
 - d. What is the spreading factor/gain?
 - e. Does the scheme tolerate errors in the received signal? To which extent? (Suggestion: determine the decoded signal for the case where the received signal has 1, 3, and 5 errors)

3. A system transmits at 30 kbps, sending 3 bits per symbol. The time between hops for a FHSS system is 0.125 ms. Is the system using slow-frequency-hop spread spectrum or fast-frequency-hop spread spectrum?

4. An FHSS system employs a total bandwidth of $W_s = 400$ MHz and an individual channel bandwidth of 100 Hz. What is the minimum number of PN bits required for each frequency hop?

5. An FHSS system using MFSK with $M = 4$ employs 1000 different frequencies.
 - a. What is the number of bits per signal element (symbol)?
 - b. What is the total number of possible carrier frequencies?
 - c. What is the total (spread) bandwidth W_s of the FHSS transmission (with respect to the bandwidth W_d of the equivalent narrowband signal)?

6. The table below illustrates the operation of an FHSS system for one complete period of the PN sequence.

| | | | | | | | | | | | | |
|-------------|-------|---|-------|---|----------|---|----------|---|-------|---|----------|----|
| Time | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| Input data | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 |
| Frequency | f_1 | | f_3 | | f_{23} | | f_{22} | | f_8 | | f_{10} | |
| PN sequence | 001 | | | | 110 | | | | 011 | | | |

| | | | | | | | | |
|-------------|-------|----|-------|----|-------|----|-------|----|
| Time | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| Input data | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 0 |
| Frequency | f_1 | | f_3 | | f_2 | | f_2 | |
| PN sequence | 001 | | | | 001 | | | |

- The system makes use of a form of FSK. What form of FSK is it?
- What is the number of bits per signal element (symbol)?
- What is the number of FSK frequencies?
- Is this a slow or fast FH system?
- What is the total number of possible carrier frequencies?
- Fill the table below with the variation of the base (or demodulated) frequency with time.

| | | | | | | | | | | | | |
|------------|-------|---|-------|---|-------|---|---|---|---|---|----|----|
| Time | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| Input data | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 |
| Frequency | f_1 | | f_3 | | f_3 | | | | | | | |

| | | | | | | | | |
|------------|----|----|----|----|----|----|----|----|
| Time | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| Input data | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 0 |
| Frequency | | | | | | | | |

7. A multi-carrier modulation (MCM) system (OFDM system), having an assigned bandwidth B , resorts to N subcarriers for an aggregate data transmission rate of R .
- What is the band occupied by each subcarrier?
 - What is, the data rate in each subcarrier (considering no adaptive modulation)?
 - What is, the bit duration in each subcarrier?
 - What would be the bit duration in an equivalent single-carrier modulation system?
 - What would be the data rate in an equivalent single-carrier modulation system?
 - So, why is MCM so important to “modern” wireless communication systems (think about the consequences of multipath-propagation)?