Multipulse modulations

Digital Communications

Year 2024 – 2025

Laboratory exercise 2(a)
Direct sequence spread spectrum modulation

Objectives

In this first laboratory session you will learn to:

- Simulate a communications system with a spread spectrum modulation by direct sequence.
- Analyze the characteristics of spread sequences and relate them to the performance obtained in single-user and multi-user systems.

Regulations and deadlines

- The Lab exercise should be carried out in groups of 2/3 students.
- Each group will have to carry out the exercises described in this document, and upload in Aula Global the Quiz in which answers to the questions raised in each section of the practical are given.
- The Quiz will be handed in at the end of the Lab session. No further report handling is needed.

1. Transmission @ Chip time (1 user)

File demoP2a.m simulates a transmission @ Chip time T_c, over an equivalent channel @Chip time $d[m]$, of the sequence transmitted to one user $A[n]$, with a particular spreading sequence. You can use demoP2a.m both sections of this Lab exercise.

The spreading factor in this section is going to be $N = 11$. We define a "particular" spreading sequence:

$$x_0[m] = 1,\ m \in \{0, 1, \cdots, 10\}, \tag{1}$$

that would be equivalent to not doing spreading.

Consider the following channel:

$$d[m] = \begin{cases} a^n, & 0 \leq n \leq 50 \\ 0, & \text{en otro caso} \end{cases} \tag{2}$$

con $a = 9/10$.

The transmission of a 4-PAM constellation with normalized levels will be considered. In the file sequences11.mat there are 3 spreading sequences of length $N = 11$ stored. We will call these sequences $x_1[m]$, $x_2[m]$ and $x_3[m]$, respectively.

Debe realizar las siguientes tareas:

- Using the spreading sequence $x_0[m]$ given in (1)
  - Compute the equivalent channel $p[n]$
  - Get the symbol error rate, P_e and the bit error rate, BER, without noise ($\sigma^2_{z_c} = 0$).
  - Get the symbol error rate, P_e and the, BER, with noise and with a noise variance @chip time $\sigma^2_{z_c} = 1$.
- For each one of the sequences in sequences11.mat:
  - Compute the channel $p[n]$.
  - Get the symbol error rate, P_e and the, BER, with noise and with a noise variance @chip time $\sigma^2_{z_c} = 1$.
  - Plot the time correlation function of each spreading sequence. (you can use MATLAB xcorr function).

  In view of the results, relate the results obtained with the correlation function of each sequence, and explain the results obtained.

2. CDMA: transmission of 2 users

One of the applications of direct sequence spread spectrum modulation is multiple access or multiplexing (simultaneous transmission of information from several users). In this case, the simultaneous transmission of data from two users will be simulated, and each of them will be assigned a different spread sequence, denoted as $x_A[m]$ and $x_B[m]$.

- With an ideal channel $d[m] = \delta[m]$, and for the next following combinations ($x_A[m] = x_1[m], x_B[m] = x_2[m]$), ($x_A[m] = x_1[m], x_B[m] = x_3[m]$), ($x_A[m] = x_2[m], x_B[m] = x_3[m]$):
  - Get the symbol error rate, P_e and the bit error rate, BER, without noise ($\sigma^2_{z_c} = 0$).
  - Get the symbol error rate, P_e and the, BER, with noise and with a noise variance @chip time $\sigma^2_{z_c} = 1$.

  Relate these results to the correlation values of each sequence, and to the scalar product between the spreading sequences.
- Repeat the previous section if both users use the same sequence, $x_2[m]$.
- Repeat the first section with the channel of the equation (2).

Bibliography

- *Comunicaciones Digitales.* A. Artés, F. Pérez González, J. Cid Sueiro, R. López Valcarce, C. Mosquera Nartallo y F. Pérez Cruz. Ed. Pearson Educación. 2007.
- *Communication Systems Engineering.* J. G. Proakis y M. Salehi. Prentice-Hall. 1994.