Multipulse modulations

Digital Communications

Year 2024 – 2025

Laboratory exercise 2(b)
OFDM modulation

Objetivos

In this laboratory exercise you will learn to:

- Simulate a communications system with discrete-time OFDM modulation.
- Analyze the characteristics of the modulation, the importance of the cyclic prefix, and relate them to the performance obtained.

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. OFDM system without Cyclic Prefix

File demoP2b.m simulates the transmission over an ideal $d[m]$ channel of a user's data stream, $A[m]$, with an OFDM modulation with N carriers and no cyclic prefix. This file may be useful for the realization of all Lab-II-b sections.

In this section we will consider a system with $N = 16$ carriers for the transmission of a 16-QAM modulation with normalized levels. For simplicity, $T = 1$ will be considered, i.e. the OFDM symbol rate is $R_s = 1$ baud (per carrier). In several cases the following channel will be considered

$$d[m] = \begin{cases} a^n, & 0 \leq n \leq 5 \\ 0, & \text{en otro caso} \end{cases} \tag{1}$$

with $a = 9/10$.

You have to do the following tasks:

- Transmitting over an ideal channel, $d[m] = \delta[m]$:

- Calculate the equivalent discrete channels $p_{k,i}[n]$, and discuss from those values whether ISI or ICI will exist during transmission.
- Estimate the symbol error probability on each carrier, and average over the N carriers if the variance of the noise added to $v[m]$ is $\sigma^2 = 4$ for each of the components (note that the noise is complex).

- Transmitting over the channel (1):
  - Compute the equivalent discrete channels $p_{k,i}[n]$, and discuss from those values whether ISI or ICI will exist during transmission.
  - Estimate the probability of symbol error on each carrier, and average over the N carriers if the variance of the noise added to $v[m]$ is $\sigma^2 = 4$ for each of the components.

2. OFDM with Cyclic Prefix

Now an OFDM system must be implemented that transmits with a cyclic prefix of C samples.

In all cases, transmission over the channel (1) will be considered.

You have to do the following tasks:

- Transmitting without noise, and for the following values $C \in \{1, 2, \cdots, 10\}$ values:
  - Calculate the equivalent discrete channels $p_{k,i}[n]$, and discuss from those values whether ISI or ICI will exist during transmission.
  - Estimate the symbol error probability on each carrier, and average over the N carriers.
- Transmit now with a noise variance over $v[m]$ of $\sigma^2 = 4$ on each of the components, and for the same cyclic prefix length values:
  - Estimate the symbol error probability on each carrier, and average over the N carriers.

In view of the results obtained, draw the most important conclusions, focusing the discussion on the optimal value for the cyclic prefix length.