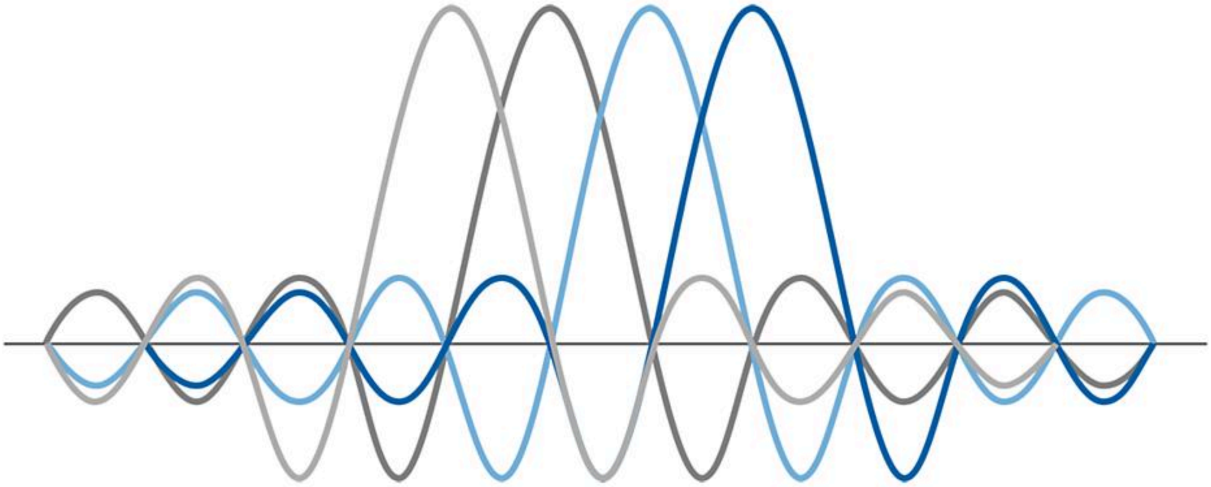

Image Transmission via OFDM System Utilizing the IEEE 802.11a WLAN Physical Layer

OFDM Implementation

CIE 478 - SPRING 2024

Dr. Mahmoud Abdelaziz

Eng. Eman Abdelnaby

Nada Adel - Nada Tayel - Touransland Ali

Introduction

The Orthogonal Frequency-Division Multiplexing (OFDM) system, is a popular modulation technique used in wireless communications. In this project, we aim to implement the OFDM system specified in the 802.11a standard. We followed the project requirements document to ensure the completion of all necessary tasks.

Advantages of OFDM:

OFDM offers several advantages, such as:

- High spectral efficiency
- Resilience to frequency-selective fading
- More resilient to electromagnetic interference
- Enables more efficient use of total available bandwidth
- The ability to accommodate multiple users through subcarrier allocation

Disadvantages of OFDM:

However, OFDM also has its drawbacks, such as:

- High peak-to-average power ratio (PAPR) of the transmitted signal, and this can lead to distortion and reduces the power efficiency.
- More sensitive to frequency offset and phase noise than other modulation techniques.
- Channel fading
- Synchronization
- Interference

Trade-offs of OFDM:

- ## peak-to-average power ratio:

One of the main challenges is the high peak-to-average power ratio of the transmitted signal, and this can lead to distortion and reduces the power efficiency. We can use many techniques to solve this issue, but each has its own trade-offs, from these techniques:

- **Clipping:**

Which is a simple and low-complexity method, but it introduces out-of-band emissions and error vector magnitude (EVM) degradation.

- **Filtering:**

It can be more effective in reducing PAPR while minimizing distortion, but it may require more computational resources and careful design considerations.

- ## Allocating Time-frequency resources:

When giving different groups of subcarriers to different users, each user's transmit power can be concentrated in a restricted part of the channel bandwidth, resulting in significant coverage enhancement. However, different user signals remain orthogonal only if time/frequency synchronization is maintained and an appropriate cyclic prefix is appended to compensate for timing misalignments at the receiver. In order to maintain good performance in frequency-selective fading channels, we must apply robust forward error correction schemes.

- ## High power amplifiers (HPAs):

HPAs are often used in wireless transmitters to boost the signal power. But HPAs can have nonlinear characteristics, especially when operating near saturation. This nonlinearity can cause significant distortion to OFDM signals, and this have a high crest factor due to the superposition of multiple subcarriers. To mitigate the effects of HPA nonlinearity, we can apply digital predistortion (DPD) techniques, which involve modeling the HPA behavior and pre-compensating the signal in the digital domain.

However, DPD may require more computational resources and careful design considerations.

Equalization in OFDM Systems:

Equalization is a very important process in OFDM systems to combat the effects of frequency-selective fading and intersymbol interference (ISI). In the project we were focusing on two popular equalization techniques which are the Zero-Forcing (ZF) equalizer and the Wiener equalizer.

- ### The ZF equalizer :

It is a linear equalizer that inverts the channel frequency response, forcing the equalized channel to have a flat frequency response. Its main advantage is its simplicity and low computational complexity. However, it can amplify and enhance noise and ISI, especially in channels with deep fades. But this noise enhancement wouldn't appear in case of high SNR.

- ### The Wiener equalizer :

It is a minimum mean-square error (MMSE) equalizer that takes into account the noise and ISI power spectral densities (PSDs) in addition to the channel frequency response. It provides a better tradeoff between noise enhancement and ISI suppression compared to the ZF equalizer, but it may require more computational resources and channel estimation accuracy.

Implementation:

Regarding the code implementation and plottings, check the matlab livescript.

References:

- Chapter 11 form:

Proakis, J. G., & Salehi, M. (2007). Digital communications. McGraw-hill.

- IEEE 802.11a standard.