**Design & Implementation of Digital Video Broadcasting Simulator**

# Project Advisor

Muhammad Rizwan

## Group Members


| | |
|---|---|
| Syed Abdullah Abbas | 060820008 |
| M Usama Jamshed | 070920039 |
| M Zulkifl Hasan | 081220227 |
| M Zunnurain Hussain | 081220228 |

# Abstract

Orthogonal frequency division multiplexing (OFDM) is becoming the chosen modulation technique for communication. OFDM can provide large data rates with sufficient robustness to channel impairments. The purpose of this report is to provide Matlab code to simulate the basic processing involved in the generation and reception of an OFDM signal in a physical channel and to provide a description of each of the steps involved. For this purpose, we shall use, as an example, one of the proposed OFDM signals of the Digital Video Broadcasting (DVB) standard for the terrestrial. [17].

This report discusses the design and implementation of an OFDM system in different data modulation schemes such as M-QPSK, M-QAM. First a brief introduction is provided by explaining the background and the specification of the project. Then the report deals with the system model. Each block of the OFDM system is described (IFFT/FFT, cyclic prefix, modulation/demodulation, channel estimation, bit error rate). In the following section, the system architecture is analyzed. The transmission techniques, as well as the system parameters for transmission and reception are explained in detail. Finally, the results are provided in the last chapter.

# Acknowledgments

We would like to thank Allah Almighty who gave us the ability and bestowed us with Perseverance to write this project report. He is the alone we always looked to in the face of trouble and He always created a way for us out of the trouble. We would not be what we are today if He did not want us to be. Our sincere thanks to the advisor Muhammad Rizwan. While Muhammad Rizwan guided us throughout our undergraduate studies in learning how to solve technical problems, and taught us how to tell others what problems have been solved. Every time we got the draft of this project report revised, we felt significant improvement in our thought process and in our writing skills. We are thankful to him for his patience during the writing process. We admit that there were errors that occurred repeatedly but he always took time to point those out. We would like to thank our friend Abdullah Saqlain Sahi who helped us out in final editing for approval. Outside the department, I enjoyed the company of numerous friends during my graduate studies at UMT. First name to be mentioned is Syed Ali Nauman Gilani & Aun Mahmood. We would like to thank the following people, whom I met at UMT, for their sincere Guidance: Mr.Farhan Iqbal, Madam Sadia Murshad , Mr.Saleem Ata, Muhammad Saadi , and Bazigh Mahmood . A number of people have impacted our studies and career, Basit Saeed, Nauman & Yousaf who are our oldest friends , always provided us support when it was needed. Our parents have been extremely supportive to us throughout the Career. It is the desire to see them happy that keep us motivating. We want to thank them. These are the people who make a difference in my life.

# Table of Contents

# List of Acronyms and Abbreviations

| | |
|---|---|
| OFDM | Orthogonal Frequency Division Multiplexing |
| QPSK | Quadrature Phase Shift Keying |
| BPSK | Binary Phase-Shift Keying |
| QAM-64 | Quadrature Amplitude Modulation |
| IFFT | Inverse Fast Fourier Transform |
| FFT | Fast Fourier Transform |
| SC | Sub Carrier |
| FDM | Frequency Division Multiplexing |
| GI | Guard Interval |
| DVB-T | Digital Video Broadcasting — Terrestrial |
| GUI | Graphical User Interface |
| ISI | Inter Symbol Interface |
| ICI | Inter Carrier Interface |
| MIMO-OFDM | Multiple-Input & Multiple-Output |
| COSSAP | Communication System Simulation and Application Processor |
| SISO | Single-Input and Single-Output |
| RRNS | Redundant Residue Number System |
| BER | Bit Error Ratio |
| AWGN | Additive White Gaussian Noise |
| MI-SBTVD | Innovative Modulation For the Brazilian digital TV System |
| SNR | Signal to Noise Ratio |
| M-PSK | M-ary Phase-Shift Keying |

| | |
|---|---|
| M-QAM | Multi-Level Quadrature Amplitude Modulation |
| D/A | Digital / Analog |
| WLAN | Wireless Local Area Network |
| DFT | Discrete Fourier Transform |
| IDFT | Inverse Discrete Fourier Transform |
| MPEG | Moving Picture Experts Group |
| COFDM | Coded Orthogonal Frequency Division Multiplexing |
| LP | Low Priority |
| HP | High Priority |
| HDTV | High Definition Television |
| SFN | Single-Frequency Network |
| MFN | Multiple Frequency Network |
| TPS | Transmission Parameter Signaling |
| CR | Code Rate |

# List of Tables

# List of Figures

# Chapter 1

# Introduction

## 1.1 Introduction

In Orthogonal frequency division multiplexing (OFDM) the basic principle is to split a high-rate data stream into a number of lower- rate data streams that are transmitted simultaneously over a number of subcarriers (SCs). Each of which is modulated on a separate SC (FDM). Thereby, the bandwidth of the SCs becomes small compared with the coherence bandwidth of the channel that is, the individual SCs experience flat fading, which allows for simple equalization. This implies that the symbol period of the sub streams is made long compared to the delay spread of the time-dispersive radio channel. Because the symbol duration increases for lower rate parallel subcarriers, the dispersion will be reduced which is caused by multipath delay spread . Inter symbol interface can be eliminated by the introduction of guard interval in the stream. By selecting a special set of (orthogonal) carrier frequencies, high spectral efficiency is obtained because the spectra of the SCs overlap, while mutual influence among the SCs can be avoided. The system model shows that by introducing a cyclic prefix (the GI), the orthogonality can be maintained over a dispersive channel. Orthogonality is a very important factor in OFDM which will be discussed in detail in further chapters. OFDM can be implemented using different parameters. We have implemented DVB-T standards for 2k,4k and 8k modes. We have also used different modulation schemes for comparison in our coding / implementation section.[1]

## 1.2 Motivation

These days in communication lots of work is being done to make optimum data transmission using different modulation schemes. People are working on different modulation techniques but most prominent is OFDM in which splitting a high-rate data stream into a number of lower-rate streams and then transmitted simultaneously over a number of subcarriers is the crux. A lot of research has been conducted on it and we have seen lots of thesis on OFDM on internet but we didn't find any OFDM implemented in GUI. What we are doing is the comparison of different modulation schemes' efficiency regarding bit error rate, if implemented using OFDM. Constellation diagrams and scatter plots have been used to show the comparison. And this all has been provided in a user friendly GUI, so that anyone can play with the variables and check for the desired outputs.

## 1.3 Previous work

People are working on OFDM as it is now a very useful technique to send data at high rate with less ISI and delay spreads. Previous work include following paper and researches listed below:

- A MATLAB program has been written to investigate Orthogonal Frequency Division Multiplexing (OFDM) communication systems. This program is valuable for future researchers simulating systems that are too theoretically complex to analyze. Single carrier QAM and multicarrier OFDM are compared to demonstrate the strength of OFDM in multipath channels. Two graphical user interface demonstrations show some of the basic concepts of OFDM.[2]
- Orthogonal frequency division multiplexing (OFDM) is a promising technique for high-data-rate wireless communications because it can combat inter-symbol interference (ISI) caused by the dispersive fading of wireless channels. The proposed research focuses on techniques that improve the performance of OFDM based wireless communications and its commercial and military applications. In particular the paper addresses the following aspects of OFDM: inter-carrier interference (ICI) suppression, co-channel interference suppression for clustered OFDM, clustered OFDM based anti-jamming modulation, channel estimation for MIMO-OFDM, and pre coding for MIMO-OFDM with channel feedback.[3]
- This paper proposes a MIMO OFDM baseband transceiver design for the next-generation high-throughput wireless LAN using two transmit antennas and two receive antennas. A MIMO OFDM receiver with algorithm for timing and frequency synchronization, tracking. channel estimation, and MIMO detection is designed and implemented in software. Simulation results show that the proposed receiver is capable of transmission with a data rate that is twice that of the current IEEE 802.1 la wireless LAN standard.[4]
- This paper suggests a novel, low power, minimally-intrusive, method of gaining an insight into power line channel behavior. The technique proposed enables the user to simulate models with power line noise and frequency / attenuation characteristics without intruding onto the channel with real time transmissions. The paper also shows the

modeling of a modem suitable for use within the in-house power line environment using Orthogonal Frequency Division Multiplexing (OFDM). A powerful, UNIX based, modeling program called "COSSAP" is then used as a platform to implement the model design.[5]

- Orthogonal frequency-division multiplexing (OFDM) is an up and coming modulation technique for communications. Herein, we consider various system design and signal processing issues for OFDM- and packet-based SISO (single-input/single output) and MIMO (multiple-input/multiple-output) wireless communication systems over time-invariant and timing-varying frequency-selective fading channels [6]
- The proposed research focuses on a concatenated coding scheme that improve the performance of OFDM based wireless communications. It uses a Redundant Residue Number System (RRNS) code as the outer code and a convolution code as the inner code. Here, a direct conversion of analog signal to residue domain is done to reduce the conversion complexity using sigma-delta based parallel analog-to-residue converter. The bit error rate (BER) performances of the proposed system under different channel conditions are investigated. These include the effect of additive white Gaussian noise (AWGN), multipath delay spread, peak power clipping and frame start synchronization error. [7]
- One of the proposals for the physical layer of this system was entitled Innovative Modulation for the Brazilian Digital TV System (MI-SBTVD). The MI-SBTVD Project includes high performance error correcting codes, transmit spatial diversity and multi-carrier modulation. The focus of this paper is two fold. First, we look at the transmit diversity scheme, which combines Alamouti coding and OFDM modulation. We then discuss the channel estimation algorithm that has been implemented in the proposed system. Pilot subcarriers are inserted among data subcarriers, and both uni dimensional and bi dimensional linear interpolation at the receiver are considered. Computer simulation results, using typical digital TV channels, show that the proposed scheme is able to perform close to the case of a perfectly known channel at the receiver. [8]
- First an overview of the OFDM system suitable for mobile communications is described. The effects of non-ideal transmission conditions of the OFDM system including channel estimation errors, symbol timing offset, carrier and sampling clock offset, phase noise

and time selective fading are analyzed. We then propose an integrated receiver in which all of these issues relevant to the mobile transmission environment are addressed. Novel techniques for symbol timing and frequency synchronization are proposed. The architecture of the receiver and resulting implementation complexity are then analyzed. The overall performance of the proposed receiver is simulated and evaluated in various channel conditions.[9]

## 1.4 Aim of project

The aim of doing this project is to provide a comparison tool for OFDM being implemented on different modulation schemes. This tool allows the user to play with different variables affecting wireless transmission like channel affect, AWGN noise, SNR, etc; in addition to, This tool has a flexibility to use either M-PSK or M-QAM technique for data modulation. Thus, it helps us to make comparisons in many ways.

# Chapter 2

# OFDM System

## 2.1 Introduction

This chapter introduces complete OFDM system, which consists of two parts Transmitter and Receiver. The actual OFDM system model used for applying specific techniques and algorithms presented in this thesis are discussed in later chapters.

Whenever we talk about communication system, we just think of two parts transmitter and receiver.

A Transmitter consists of following parts:

- Serial to parallel converter
- Constellation mapper
- IFFT block used here for generation of subcarriers
- Adding Cyclic Prefix and Zero padding
- Parallel to serial converter used here to give input to D/A up conversion
- D/A
- Up conversion
- Adding channel

Similarly, Receiver consists of following parts:

- Down Conversion
- A/D
- Serial to Parallel converter after that Cyclic prefix removed