Chapter 1

Introduction to OFDMA systems

1.1 EVOLUTION OF OFDM SYSTEM

Modulation - *Mapping of the information onto the carrier which changes the carrier phase, frequency or amplitude or combination.*

Multiplexing – *Bandwidth sharing method with other independent data channels.*

In the mid 1960's Frequency Division Multiplexing (FDM) as shown in Fig.1.1 has been evolved in which the subcarriers are spread over the available bandwidth with guard spacing in between them. This guard spacing is provided to protect the signal from overlapping which causes Inter Signal Interference or Inter Carrier Interference. But this is very soon replaced by Orthogonal Frequency Division Multiplexing to increase the transmission rate.

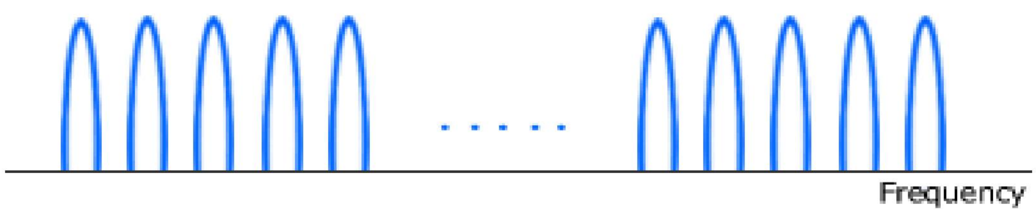

Fig.1.1. Frequency Division Multiplexing

In order to use the bandwidth more efficiently, Orthogonal Frequency Division Multiplexing (OFDM) was proposed and used in IEEE 802.16d, where all the carriers are placed orthogonal to each other as shown in Fig.1.2. With OFDM, since all the carriers are orthogonal to each other, they can be placed by overlapping to each other by which the carriers will be placed close to each other resulting in increase of the transmission rate and also bandwidth will be efficiently used . OFDM has been used for high data rate applications and also it has been referred as fixed service i.e. OFDM-256 FFT mode.

A signal is group of symbols which are Modulated and Multiplexed in the OFDM. These multiplexed symbols form OFDM carrier which is to be transmitted to the receiver. Unlike FDM, in OFDM a large number of subcarriers which are orthogonal to each other and overlapping are transmitted in parallel. Very compact spectral utilization is achieved in OFDM.

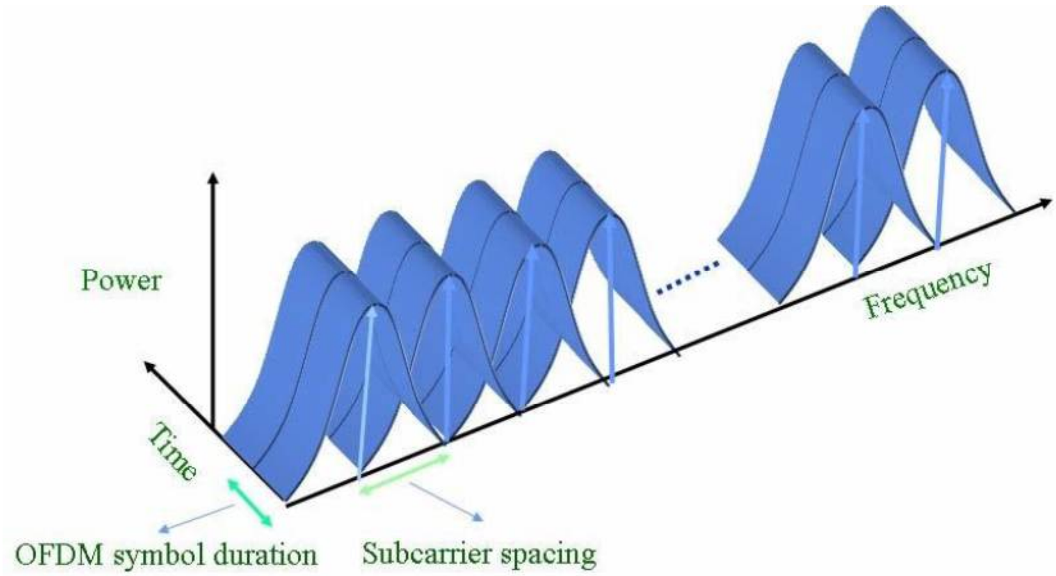

Fig.1.2. Time-Frequency plot of Orthogonal Frequency Division Multiplexing signal

As an analogy, a FDM channel is like a continuous water flow coming out of a faucet, the whole bunch of water coming all in one straight stream as shown in the Fig. 1.3(a); In contrast the stream of water in OFDM signal is like a shower in which the continuous water flow is flowing in the form of lot of small streams. In a faucet continuous water comes in one big stream and further it cannot be sub-divided. OFDM shower signal is made up of a lot of little streams as shown in Fig. 1.3(b).

Fig 1.3 (a) A regular FDM- single carrier (b) Orthogonal-FDM

The clear advantage of OFDM over FDM is that when one puts thumb over the continuous water flow from the faucet, the water flow will be stopped, where as it is not possible to stop in the shower. Although both do the same water flow, they respond differently when there is interference during the flow. Both methods carry the exact and same amount of information. But only some part of the information will get disturbed in the presence of interference in the case of OFDM.

1.1.1 Introduction to OFDMA Technique

Orthogonal Frequency Division Multiple Access (OFDMA) is a multi-user version of the popular OFDM scheme. Multiple access is achieved in OFDMA by assigning subsets of subcarriers to individual users as shown in the illustration Fig. 1.4. This allows simultaneous low data rate transmission from several users.

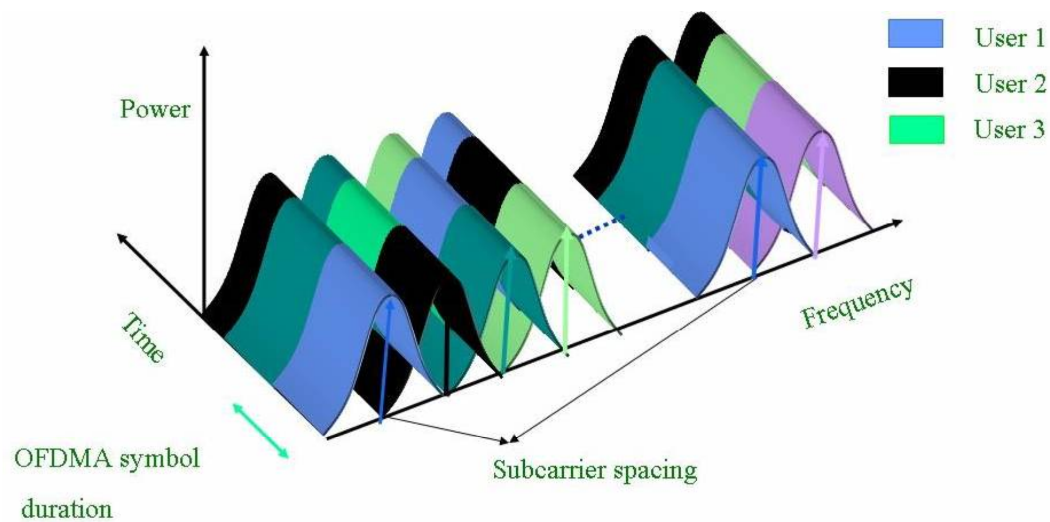

Fig.1.4. Orthogonal Frequency Division Multiple Access signal

The technology works by splitting the radio signal into multiple smaller sub-signals that are then transmitted simultaneously at different frequencies to the receiver. OFDM/A reduces the amount of crosstalk in signal transmissions. In OFDMA, Fixed 2048-point FFT was conceived and also supported by IEEE 802.16e i.e. mobile broad band services. There is also scalable OFDMA (SOFDMA) which computes variable length FFT like 128-pt FFT, 512-pt FFT, 1024-pt FFT and 2048-pt FFT. So, scalable OFDMA can actually shift its size depending on the channel and bandwidth.

1.2 INTRODUCTION TO OFDMA SYSTEM

The serial data is converted to parallel data and digital modulation scheme like M-PSK or M-QAM is applied to form the symbols and process the Inverse Fast Fourier Transform (IFFT). Cyclic prefix is added at the end of the each symbol to indicate the end of each symbol at the receiver and hence the OFDM/A symbols are obtained which is to be transmitted into the channel as shown in the Fig. 1.5. At the receiver point of view both the OFDM and SOFDMA techniques are same since at an instance of given time OFDM performs fixed point FFT i.e. 256-pt FFT and OFDMA can perform variable length FFT.

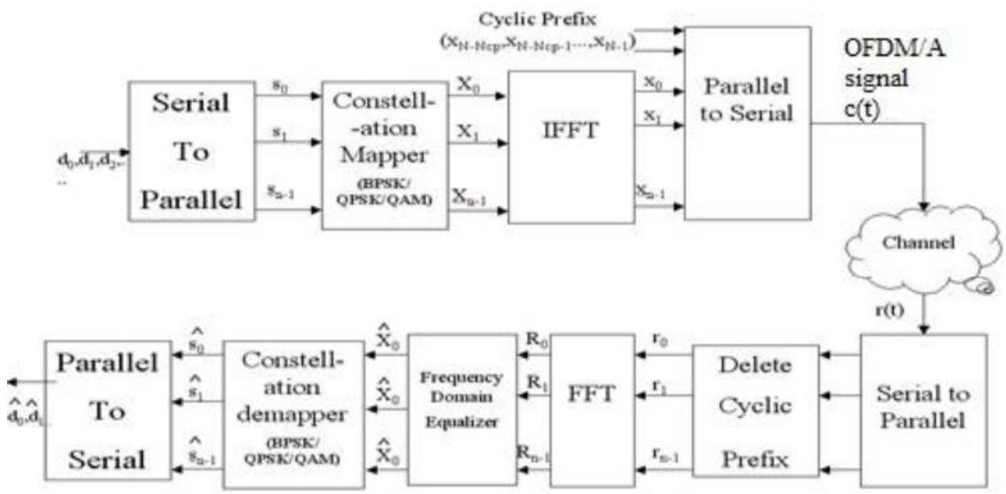

Fig.1.5: An OFDM/A communication Architecture with Cyclic Prefix

As an example in OFDMA a user travelling in a cell with some speed might receive the signal from any one of the 128-pt FFT, 512-pt FFT, 1024-pt FFT or 2048-pt FFT depending on the factors like channel or bandwidth. Subcarrier-group, sub-channels can be matched to each user to provide the best performance, which results in the least problems with fading and interference based on the location and propagation characteristics of each user [1], [2].

1.3 SYMBOL INTERFERENCE IN OFDM/A SYSTEMS

OFDM/A is considered as a multicarrier modulation system. The transmitting channel will be divided into N- number of paths called sub-channels and each path is assigned a sub-Carrier. Inter- Symbol Interference (ISI) or Inter-Carrier Interference (ICI) will occur when the signal is transmitting through a non-ideal channel resulting in the performance degradation of the system. The level of degradation and the performance aspects depends on the frequency response characteristics of the transmitted channel. Since the channel is Non-Ideal and the system performance is affected by ISI, the receiver complexity is increased [3]. Two factors of constraints are usually required for designing the system; they are the receiver complexity constraints and transmitted signal power constraints. Within these constraints, the main task of a designer will be to transmit the information onto the channel by using the channel bandwidth efficiently. When a single carrier system is employed in which the sequence of messaging data is transmitted in serial at some specified transmission rate R symbols per second, the time dispersion of the non-ideal channel is normally much greater than the symbol duration. Hence, ISI will greatly affect the receiver system. For this reason, an equalizer is required to compensate the ISI caused by multipath within the time dispersive channels of the system [4], [5], [6], [7].

In a basic communication system, the various signal processing techniques to improve the link between transmitter and receiver are Equalization, Diversity and channel coding. The Equalization compensates the ISI caused by multipath; Diversity is the technique used to compensate the fast fading which is experienced by the receiver in a flat fading channel and channel coding is used to correct deep fading and spectral null by appropriate coding technique. The basic idea of OFDM/A is to divide the available spectrum into several orthogonal sub channels so that each narrowband sub channels experiences almost flat fading. The attraction of OFDMA is mainly because of its way of handling the multipath interference at the receiver. Multipath phenomenon generates two effects (a) Frequency selective fading and (b) Inter-symbol interference (ISI). The "flatness" perceived by a narrowband channel overcomes the frequency selective fading. On the other hand, modulating symbols at a very low rate makes the symbols much longer than channel impulse response and hence reduces the ISI. Use of suitable error correcting codes provides more robustness against frequency selective fading. The use of 2D-FFT technique to implement modulation and demodulation functions makes it computationally more efficient. OFDMA systems have gained an increased interest during the last couple of years. It is also used in the European digital broadcast radio system, as well as in wired environment such as asymmetric digital subscriber lines (ADSL). This technique is used in digital subscriber lines (DSL) to provide high bit rate over a twisted-pair of wires.

The major advantage of OFDMA is its ability to convert a frequency selective fading channel into several nearly flat fading channels and high spectral efficiency. However, one of the main disadvantages of OFDM/A is its sensitivity against carrier frequency offset in high speed transmission which causes attenuation, rotation of subcarriers and delayed symbol arrivals at the receiver causing ISI or ICI [8], [9] which degrades the performance of the system.

1.4 LITERATURE REVIEW

1.4.1 Craciunescu et al. Multi User Orthogonal Frequency Division Multiple Access (MU-OFDMA) Performances in AWGN and Fading channels

This paper presents the performances of BPSK, QPSK, 16-QAM, 64-QAM /Multi User Orthogonal Frequency division Multiple Access (MU-OFDMA) and orthogonal frequency-division multiplexing (OFDM) systems performances in terms of Bit Error Rate (BER) as a function of Signal to Noise Ratio (SNR) using different lengths of Cycling Prefix. The simulations were carried out over AWGN and Rayleigh fading channels, and the results for the two systems have been compared. The results show that the MU-OFDMA system is more robust to changes in CP lengths and in fading environments. Moreover, the results of the simulations conclude that the MU-OFDMA system is better that the OFDM system regardless the modulation order, or the CP length. In an AWGN only environment, the data rates up to six times with the same SNR can be obtained by the OFDM system. For a MU-OFDMA multiuser case, the users were affected in the same manner by the communications channel, obtaining thus a great advantage over other types of multiple access techniques.

1.4.2 Sudhir et al. Evaluation of BER for AWGN, Rayleigh and Rician Fading channels under various modulation Schemes.

In this paper, several transmission modes are defined in IEEE 802.11 a/b/g WLAN standards. A very few transmission modes are considering for IEEE 802.11 a/b/g in physical layer parameters and wireless channel characteristics. The performance an IEEE 802.11b standard has been carried out using straight forward evaluation. The BER vs SNR have been calculated for the three channels i.e. AWGN channel, Rayleigh and Rician channels. Multipath propagation has also been considered.

The simulation results had shown the performance of transmission modes under different channel models and the number of antennas. Based on simulation results, it has been observed that some transmission modes are not efficient in IEEE 802.11b. The evaluation of performance confirms the increase in the coverage area of the physical layer in the 802.11b WLAN devices.

1.4.3 Alessandro et al. Adaptive subcarrier allocation schemes for Wireless OFDMA systems in WiMAX networks

In this paper, the use of OFDM transmissions has been proposed to reduce the effect of multipath fading in wireless communications. Moreover, multiple access is achieved by resorting to the OFDMA scheme. Adaptive subcarrier allocation techniques have been selected to exploit the multiuser diversity, leading to an improvement of performance by assigning sub-channels to the users accordingly with their channel conditions. The method to allocate subcarriers is to assign almost an equal bandwidth to all users which is called fair allocation. However, it is well known that this method limits the bandwidth efficiency of the system. In order to lower this drawback, in this paper, two different adaptive subcarrier allocation algorithms are proposed and analyzed. Their aim is to share the network bandwidth among users on the basis of specific channel conditions without losing bandwidth efficiency and fairness. Performance comparisons with the static and the fair allocation approaches are presented in terms of bit error rate and throughput to highlight the better behavior of the proposed schemes in particular when users have different distances from the base station. The first proposed method, named proportional allocation scheme, assigns different amounts of capacity to users, proportionally to the channel conditions seen by each user; the second strategy, named equal capacity increment approach, provides an equal increase of capacity to all the users with respect to a non-adaptive slot allocation technique. The proposed algorithms permit to achieve a better trade-off between fairness and bandwidth efficiency respect to the fair allocation and show a performance increase with respect to a statistical allocation independently of channel conditions and at any distance from the base station.

1.4.4 A. Idris et al. Reduction of ISI using different Equalization of Adaptive Algorithm for Mobile WiMAX Communication System

Different equalization of adaptive algorithm technique had been proposed in this research paper in order to reduce ISI in OFDMA system. This research also proved the combination of space time frequency block code (STFBC) with multiple input multiple output (MIMO) antenna enable to overcome ISI by using IEEE 802.16 simulation parameter. The simulation results show the improvement of bit error rate (BER) performance after reducing ISI and also prove that STFBC was able to achieve maximum diversity order in the MIMO OFDMA system.

adaptive decision feedback equalizer proved that it can eliminate ISI in MIMO OFDMA system and improve BER performance by using different type of adaptive algorithm like LMS, RLS and CMA. The STF codes scheme combination with MIMO antenna also helps to overcome ISI problem in the system. Besides that, STF also proved that higher diversity will increase the reliability of the MIMO OFDMA system. RLS algorithm is most suitable for adaptive decision feedback equalizer use for MIMO OFDMA. LMS and CMA can also give better performance when step size and forgetting factor use is suitable for the system.

1.4.5 Pawan Verma et al. VHDL implementation of FFT/IFFT Blocks for OFDM.

This paper gives the details of the development of IFFT & FFT algorithms to be used in OFDM systems based on the IEEE 802.11a standard for WLAN. The speed enhancement is the key contribution of the main processing blocks in OFDM system i.e. IFFT and FFT. And the same has been implemented in VHDL. The comparison between DFT and FFT has been carried out. The device utilization summary shows that the number of clock cycles required is reduced and both blocks gives the final outputs as desired. the 8-point IFFT & FFT algorithms using VHDL to be used in the 802.11a architecture of OFDM transmitter & receiver. The performance of the main processing block of OFDM transceiver is upgraded by reducing the clock cycles. The accuracy in obtained results has been increased with the help of efficient coding in VHDL. The accuracy in results depends upon the equations obtained from the butterfly diagram and then on the correct drawing of scheduling diagrams based on the IFFT and FFT equations.

1.4.6 Chi-Li et al. FPGA Architecture for 2D Discrete Fourier Transform based on 2D Decomposition for Large-sized Data

Architectures based on RC decomposition are not efficient for large size input data due to memory bandwidth constraints. In this paper, we propose an efficient architecture to implement 2D DFT for large-sized input data based on a novel 2D decomposition algorithm. This architecture achieves very high throughput by exploiting the inherent parallelism due to the algorithm decomposition and by utilizing the row-wise burst access pattern of the external memory. A high throughput memory interface has been designed to enable maximum utilization of the memory bandwidth. In addition, an automatic system generator is provided for mapping this architecture onto a reconfigurable platform of Xilinx Virtex-5 devices. For a 2K × 2K input size, the proposed architecture is 1.96 times faster than RC decomposition based implementation under the same memory constraints, and also outperforms other existing implementations.

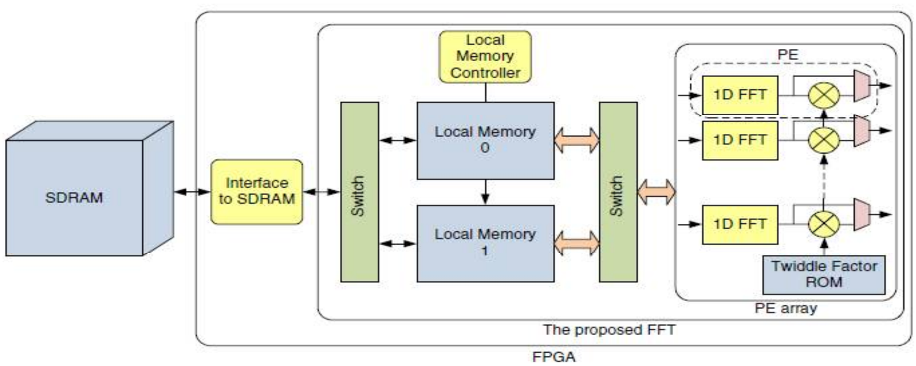

Fig.1.6. proposed 2D-DFT architecture in paper

1.4.7 Wen-Chang et al. High-Speed and Low-Power Split-Radix FFT

This paper presents a novel split-radix fast Fourier transform (SRFFT) pipeline architecture design. A mapping methodology has been developed to obtain regular and modular pipeline for split-radix algorithm. The pipeline is repartitioned to balance the latency between complex multiplication and butterfly operation by using carry-save addition. The number of complex multiplier is minimized via a bit-inverse and bit-reverse data scheduling scheme. One can also apply the design methodology described here to obtain regular and modular pipeline for the other Cooley–Tukey-based algorithms. For an N (= 2^n) point FFT, the requirements are $\log_4$ (N- 1) multipliers, 4 $\log_4$ N complex adders, and memory of size N-1 complex words for data reordering. The initial latency is N+2$\log_2$N clock cycles. On the average, it completes an N-point FFT in N clock cycles. From post-layout simulations, the maximum clock rate is 150 MHz (75 MHz) at 3.3 v (2.7 v), 25^0 C (100^0 C) using a 0.35- µm cell library from Avant. A 64-point SRFFT pipeline design has been implemented and consumes 507 mW at 100 MHz, 3.3v, and 25^0 C. compared with a radix-2^2 FFT implementation, the power consumption is reduced by an amount of 15%, whereas the speed is improved by 14.5%. The 1-D linear array for the other FFT algorithms can be obtained via similar mapping procedure, and the delay-balanced pipeline architecture can also be used when higher clock rate and lower power consumption are desirable. The comparison of the fixed-radix and mixed-radix algorithms also provides useful information for a designer.

1.4.8 Wen-Rong et al. ISI mitigation and channel tracking in MIMO-OFDM systems.

In this paper, the ISI and ICI mitigation in MIMO-OFDM systems has been considered. Decision feedback equalizer technique for ISI cancelation and a cyclic reconstruction technique for ICI removal were implemented. Combining with the V-BLAST method, an iterative signal detection algorithm for MIMOOFDM systems has been implemented. Since the channel may be time-variant, an adaptive time-domain channel tracking method has been proposed. The algorithm has been implemented with IFFT so that its computational complexity is low. Simulations demonstrate that the proposed method can effectively enhance the overall MIMO-OFDM system performance with the comparisons between the conventional OFDM and the proposed MIMO-OFDM multiple iterations.

1.5 RESEARCH GAP

There are many algorithms and techniques used for the reduction of the interference in the OFDMA out of which Frequency domain equalization, Time domain windowing, Pulse shaping, ICI self-cancellation techniques. The frequency domain equalization technique were devised for quasi-static channels and such equalization techniques suffer from interference and the system performance is degraded in the high data rate applications i.e. fast fading channels [10], [11]. Time domain windowing technique suppresses the side lobes of OFDM/A signal by raised cosine window in the time domain. The study in the [12] has reserved a guard band between the neighboring cells and maintained a higher roll-off factor for the better side lobe reduction. Similarly [13] shows that the data samples of the tail subcarriers in an OFDM symbol are encoded with the data samples of the head ones in the same OFDM symbol to reduce the interference. The disadvantage of such technique is that it is used only for band limited channels which is not the main source of interference. The interference is caused by frequency mismatch between the transmitting side and receiving side and the Doppler shift. The pulse shaping filters [14], [15] work on the time-frequency well-localized OFDM/QAM with arbitrary length and arbitrary overlapping factors. The main disadvantage of pulse shaping technique is its complexity in implementation. The ICI self-cancellation [16] scheme is a technique in which redundant data is transmitted onto adjacent sub-carriers such that the ICI between adjacent sub-carriers cancels out at the receiver. The main disadvantage of ICI self-cancellation technique is its complexity in implementation and the frequency offset.

1.6 PROBLEM STATEMENT

A transmitted signal includes series of consecutive symbols may arrive at the receiver via multiple signal paths with different delays [17], [18] and [19] .The main processing in OFDMA lies within the physical layer in which Inverse Fast Fourier Transform (IFFT) operation is carried out at the transmitter side and

Fast Fourier Transform (FFT) operation is carried out at the receiver side. When the signal is decoded, in different signal paths only a part of a symbol for a signal path may be captured in FFT window due to the multiple signal path delays, leading to Inter-symbol interference (ISI), inter-channel interference (ICI), and power loss [20].

Various methods are given for the reduction of Inter- symbol Interference like developing a channel equalizer, estimating the channel response with zero forcing equalizer, MMSE equalizer etc. in the literature study. 2D-Minimum Mean Square error gives the improved estimation performance of channel estimation by taking into the account of correlations along time and frequency that exist among the neighboring Channel Frequency Response (CFR) coefficients [21]. However, it is not so easy to realize 2D-MMSE channel estimator in most practical wireless/cellular multi-carriers systems, because of at least one of the following three reasons: First, the assigned block of sub-carriers to each user is often changed by the MAC layer scheduler, thereby complicating the task of channel correlation function estimation. Second, the estimation of the correlation function itself sustains additional computational complexity and third, an inaccurate estimate of the correlation function may lead channel estimation MSE to an uncontrolled degradation with no bound on the worst case performance. And also still there is some loss in the spectral efficiency [22], [23].

To overcome such drawbacks, a Time Tracking Loop (TTL) may be maintained to track the symbols and position the FFT window such that the FFT processing starts at the receiver only when complete symbols have arrived. This results in increase of overall signal-to-noise ratio by reducing ICI, reducing ISI, and/or increase signal power. Moreover, a linear operation is performed on received samples of a symbol prior to performing the FFT to surge the SNR. In the dissertation, estimation technique exploits the use of time variant –frequency selective fading nature of the channel which has its high impact on the modern high data rate systems and long delay spread channels.

Another important interference effect is due to radio frequency i.e. radio frequency interference (RFI) to the OFDM systems. RFI are divided into two types; narrowband interference and broadband interference [24]. The base of narrowband interference are produced from transmissions such as radio and TV stations, pager transmitters, microwave ovens and cell/cordless phones etc. [25]. The Narrowband interference may be defined as a bandpass signal whose bandwidth is much less than that of an OFDM signal's bandwidth [26]. The narrowband interference spectrum is vested within an OFDM spectrum. The OFDM subcarriers which are adjacent to it may be affected by the interference. Due to this effect, the performance of OFDM systems is degraded. On the other type, Broadband interference, as the name suggests, is caused by the devices interfering over a very broad spectrum with rich harmonic content, by which characteristics, the interference spectra is surrounded within almost every subcarrier in an OFDM symbol. The receiver will also be less effective to filter such interference. This dissertation focusses mainly on mitigation of signal interference of the type narrowband. The broadband interference mitigation may be left for future research.

1.7 THESIS OBJECTIVES

The Objective section is divided into two sections:

i. Main Objective

- The Main Objective is to design and validate a FFT Window Positioning based OFDMA system as replacement to the conventional OFDMA system in order to minimize the narrow band Inter Symbol Interference or Inter Carrier Interference which is caused by multipath propagation of symbols. In this approach, in the physical layer of OFDMA the FFT processing at the receiver side will be started only after the entire symbols have been received at the receiver. To validate the window positioned FFT-OFDMA system on FPGA hardware with VHDL environment.

ii. Specific Objectives

- To carry out the comparison between various digital modulation schemes to choose the best digital modulation scheme for the FFT- window positioned OFDMA system. This modulation type is chosen for this research based on the performances with respect to their Bit Error Rate (BER) vs Energy per bit Eb/No.

- To implement variable length FFT processor for OFDMA system using 2D-FFT algorithm to improve the overall system performance in terms of optimization of memory hardware and system level parallelism operations over normal FFT algorithm. In this objective we design an FFT processor by 2D-FFT algorithm which can implement 128-pt FFT, 512-pt FFT, 1024-pt FFT and 2048-pt FFT.

- To calculate the time taken by the OFDMA system to compute 128-pt FFT, 512-pt FFT, 1024-pt FFT and 2048-pt FFT theoretically and practically with different delay test cases.

- To carry out the comparison between different equalizers in terms of BER, which improves the link between transmitter and receiver by mitigating the inter symbol interference caused by the multipath fading.

- To implement the FFT window positioning OFDMA system by delaying the FFT process ensuring all the symbols have been arrived at the receiver to mitigate the signal interference.

- Validation of the FFT window positioned OFDMA by applying to DVB-H and DVB-T. The study should perform the BER performances for both conventional and FFT window positioned OFDMA.

1.8 ORIGINAL CONTRIBUTIONS

1. A new approach of study on nature of channel fading has been carried out for different channels. The comparison of the performance of OFDM system using Quadrature Amplitude Modulation (QAM) under the influence of AWGN, Rayleigh, and Rician fading channels is analyzed. Simulation of OFDM signals are carried out with different faded signals by increasing the number of OFDM frames in AWGN, Rayleigh and Rician fading channels to understand the effect of channel fading and to obtain optimum value of Bit Error Rate (BER) for different number of antennas. All this work has carried out through the Matlab software and observed the result through the various graphs and concluded that Modulation schemes should achieve low bit error rate in the presence of fading. This contribution was published in International Journal of Applied Engineering Research ISSN 0973-4562 Volume 10, Number 19 (2015) pp 39911-39916.

2. A new approach of the designing of Variable length FFT processor has been done, in which instead of using normal FFT algorithm,2D-FFT algorithm has been used to compute the complex multiplications and additions of 128-pt, 512-pt,1024-pt and 2048-pt FFT's. And also to Ping-Pong memory architecture is considered to store the real and imaginary values of FFT. A DDS-core was used to generate a cosine signal of frequency 50 MHz in which all the input points will be covered. This particular 2D-FFT implementation has been simulated in Model sim software and was implemented on vertex-6 FPGA board by using VHDL language. The results show that the FFT processing correct and design precision is 16-bit. Therefore the same hardware can be applied real-time FFT processing. This led to submission of publication in International Journal of Applied Engineering Research ISSN 0973-4562 Volume 10, Number 24 (2015) pp 43923-43925.

3. In the high data rate applications, as the symbol duration will be very short and receiver complexity is significantly increased, Mitigation of signal interference becomes one of the important tasks in OFDMA system. As a replacement to the conventional OFDMA, FFT window positioning in the presence of interference technique was used to reduce the ISI and increase the SNR & signal power. Farrow filters have been used to provide the necessary fractional delay. The proposed time tracking topology is a fast digital feedback loop which corrects the timing errors for OFDM based broadcast based systems, such as DVB-H and DVB-T. This contribution was published in International Conference on Intelligent Systems, Control & Manufacturing Technology (ICICMT'2015) March 16-17, 2015 Abu Dhabi (UAE).

4. A novel study is conducted on the performances of two different types of implementation of OFDMA system. First being the conventional OFDMA and the other being the FFT window positioned OFDMA. The results show that the window positioning technique has significantly less BER when compared to the conventional OFDMA. This contribution was presented in ARPN Journal of Engineering and Applied Sciences.

1.9 THESIS ORGANIZATION

The Dissertation contains seven chapters and are organized as follows

Chapter 2: Fourier based OFDM/A

An overview of the conventional OFDM/A is made in this chapter. As this OFDM/A system is multicarrier system, it uses cyclic prefix which gives many advantages to deal with multipath effect. This cyclic prefix is kept longer than the channel impulse response in order to reduce ISI/ICI. This chapter provides system process and model of FFT-OFDM/A. It also discusses the orthogonality, cyclic prefix, IFFT and FFT operations. The introduction to 2D-FFT algorithm is provided at the end of this chapter.

Chapter 3: Implementation of 2D-FFT algorithm for OFDMA/FPGA based VLSI design

In the third chapter the FPGA based VLSI design is studied and then the implementation of variable length FFT processor is carried out by using 2D-FFT algorithm. This implementation uses a DDS-core to generate a cosine signal which can cover all the input points i.e. 128-pt, 512-pt, 1024-pt and 2048-pt for the FFT processing and also discusses about Ping-Pong memory architecture which is used to store the real and imaginary values.

Chapter 4: Digital Modulation Scheme and Channel Selection

In the fourth chapter detailed description of channel simulation under AWGN, Rayleigh and Rician fading channels has been carried out. The choice of digital modulation technique is also simulated between M-PSK and M-QAM. The BER calculation of AWGN, Rayleigh and Rician fading channels was carried out. And also the BER of Rayleigh fading channel under various OFDM frames has been carried out and finally the RMS delay spread and coherent bandwidth were discussed.

Chapter 5: Mitigation of ISI by Equalization Techniques

In this chapter different types of equalizers and equalizer algorithms have been studied in order to reduce the Inter symbol interference caused by multi path propagation. The mathematical frame work of the equalizer has been carried out. The structure of zero forcing equalizer and a generic adaptive equalizer has been discussed. Comparison between different equalizer algorithms like LMS, RLS and CMA algorithms has been done and the BER was derived at the end of the chapter

Chapter 6: Proposed tracking loop enhancements for mitigating signal interference.

In this chapter the simulation and synthesis results of variable length FFT processor for different delays have been carried out and also the FFT window positioning in the presence of interference has been implemented on the hardware. Two types of OFDMA system are implemented and compared. First being the conventional OFDMA system and the other being the proposed window positioning of FFT based OFDMA system. The standard parameters approved by ETSI in 2k mode are considered to simulate the same. And synthesis is carried on VERTEX-FPGA board and results are verified for various delays produced by the International Telecommunication Union (ITU).

Chapter 7: Conclusions and Future directions

This chapter summarizes the main conclusions, outcomes and detailed Xilinx report description of this dissertation and presents possible future directions. Suggestions and ways of improvement for the future research are also given for the reference.