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A Review on OFDM Technique & ITS Implementation

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Abstract: ***Orthogonal Frequency Division Multiplexing (OFDM) is a multi-carrier system where data bits are encoded to multiple sub-carriers, while being sent simultaneously. This results in the optimal usage of bandwidth. A set of orthogonal sub-carriers together forms an OFDM symbol. To avoid ISI due to multi-path, successive OFDM symbols are separated by guard band. This makes the OFDM system resistant to multi-path effects. This paper aims to highlight various implementation techniques that have been used earlier for OFDM implementation.***

Keywords: OFDM, BER , PAPR , Wavelet Transform , Discrete cosine transform , FFT & IFFT

1. Introduction to OFDM

Orthogonal Frequency Division Multiplexing (OFDM) is a special case of multicarrier transmission, where a single data stream is transmitted over a number of lower rate subcarriers. The main reason to use OFDM is to increase the robustness against the selective fading or narrowband interference. In single carrier system if signal get fade or interfered then entire link gets failed where as in multicarrier system only a small percentage of the subcarriers will be affected. The total signal bandwidth, in a classical parallel data system, can be divided into N non-overlapping frequency sub-channels. Each sub-channel is modulated a separate symbol and then N sub-channels are frequency multiplexed. The general practice of avoiding spectral overlap of sub-channels was applied to eliminate inter-carrier interference (ICI). This is shown in Fig.1 (A). This resulted in insufficient utilization of the existing spectrum. An idea was proposed in the mid 1960s to deal with this wastefulness through the development of frequency division multiplexing (FDM) with overlapping sub-channels. The sub-channels were arranged so that the sidebands of the individual carriers overlap without causing ICI. This principle is shown in Fig 1 (B). To achieve this, the carriers must be mathematically orthogonal. From this constraint the idea of Orthogonal Frequency Division Multiplexing (OFDM) was born.

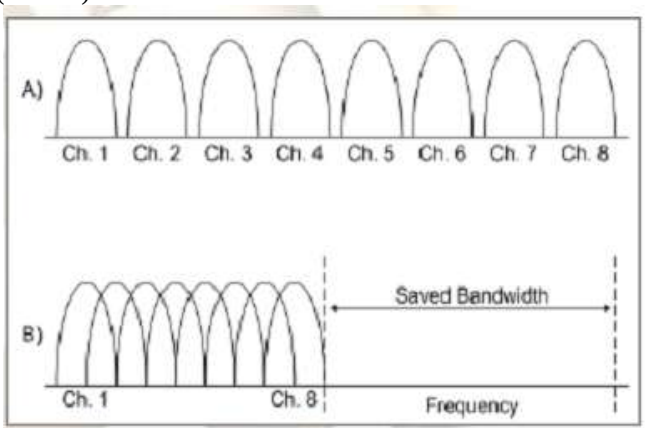

Figure 1: A) spectrum of FDM showing guard bands

OFDM is a combination of modulation and multiplexing. Multiplexing generally refers to independent signals, those produced by different sources. In OFDM the signal itself is first split into independent channels, modulated by data and then re-multiplexed to create the OFDM carrier. OFDM is a special case of Frequency Division Multiplex (FDM).

2. Digital OFDM System

Mathematically modulating a waveform and adding it is equivalent to taking an IFFT. This is because the time domain representation of OFDM is made up of different orthogonal sinusoidal signals which are nothing but inverse Fourier transform. The block diagram of digital OFDM system is shown in Fig 2.

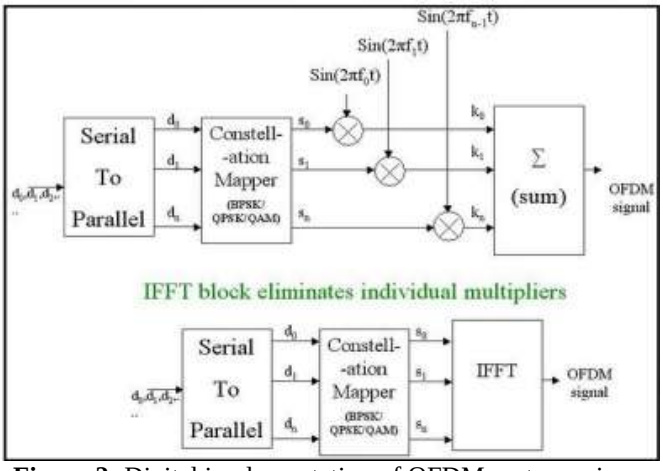

Figure 2: Digital implementation of OFDM system using IFFT and FFT

Since the OFDM signal is in time domain, IFFT is the appropriate choice to use in the transmitter, which can be thought of as converting frequency domain samples to time domain samples. Fig. 2 illustrates how the use of IFFT in the transmitter eliminates the need for separate sinusoidal converters. IFFT and FFT blocks in the transmitter are interchangeable as long as their duals are used in receiver.

3. Various Implementation Scenarios for OFDM

In 2013 Minaxi , Prabha&Rajan in their research paper titled **Evaluation Of BER For Various Fading Channel In DWT Based MIMO-OFDM System** presented DWT based MIMO-OFDM systemr. Compare to the FFT based MIMO-OFDM it has lot advantages. There is no need for cyclic prefix, flexibility and optimal resolution. Ripple(Wavelet) concept has developed as a fresh scientific implement with the aim of preserve be functional in several applications such as processing of image, biomedical manufacturing, radar, physics, organize systems also message systems. The essential region of purpose of ripples in communication system: numerous accesses. A fresh modulation/multiplexing scheme consuming ripple transform remained planned for (3rd production organization project) 3GPP systems. This fresh modulation system implemented in (orthogonal frequency division multiplexing) OFDM scheme in addition to conventional based(FFT) transform blocks is replaced by wavelet transform blocks. There are many multiplicity of ripple transforms are offered, out of which four were chosen. They are Haar, Daubechies, Bi-orthogonal and reverse Bi-orthogonal transforms. Haar wavelet is best one of among all types of wavelet. The performance of DWT based MIMO-OFDM is calculated by bit error rate (BER) in various channel that is AWGN channel and Rayleigh channel. Using MATLAB-Simulation which channel is best for the DWT based MIMO-OFDM.

In 2013 Bine Mathews and others in their research work titled **"BER Comparison of DCT and FFT Based OFDM Systems in AWGN and RAYLEIGH Fading Channels With Different Modulation Schemes"**presented a system DCT based OFDM system and FFT based OFDM system for calculating BER in AWGN and Rayleigh fading channels using BPSK and QPSK as modulating schemes. In addition to this, the BER performance over AWGN and Rayleigh fading channel are compared to estimate their performance. The results indicate that DCT based OFDM system performs better than FFT based OFDM system using BPSK as modulation scheme over AWGN channel. DCT based OFDM system surpass FFT based OFDM system.

In 2011 Veena&Swamy in their research paper titled **Performance analysis of DWT based OFDM over FFT based OFDM and implementing on FPGA**propose a DWT-IDWT based OFDM transmitter and receiver that achieve better performance in terms SNR and BER for AWGN channel. It proves all the wavelet families better over the IFFT-FFT implementation. The OFDM model is developed using Simulink, various test cases have been considered to verify its performance. The DWT-OFDM using Lifting Scheme architecture is implemented on FPGA optimizing hardware, speed & cost. The wavelet filter used for this is Daubechies (9, 7) with N=2. The RTL code is written in Verilog-HDL and simulated in Modelsim. The design is then synthesized in Xilinx and implemented on Virtex5 FPGA board and the results were validated using ChipScope.

In 2010 Abbas in his research paper titled **A Novel Radon-Wavelet Based OFDM System Design and Performance Under Different Channel Conditions** both Finite Radon Transform and Discrete Wavelet Transform are implemented in a new design for orthogonal frequency division multiplexing. The new structure was tested and compared with conventional Fast Fourier Transform -based orthogonal frequency division multiplexing, Radon-based orthogonal frequency division multiplexing, and discrete wavelet transform -based orthogonal frequency division multiplexing for additive white Gaussian noise channel, flat fading channel, and multi-path selective fading channel. Simulation tests were generated for different channels parameters values. The obtained results showed that proposed system has increased spectral efficiency, reduced inter symbol interference and inter carrier interference, and improved bit error rate performance compared with other systems.

4. Analysis of Above Works and Problem Formulation

Following problems were identified based on the above literature review:-

1) The analysis of the systems discussed in the literature consists primarily of a single type of channel. Their research development was concentrated on a single channel.
2) There is wide number of research work on wavelet based OFDM systems based on FFT , IFFT and DCT but little attention has been paid on the implementation and design of wavelet based OFDM system.
3) Several models and research work on OFDM focused on the individual analysis of systems that includes BER, SNR, but a comparative analysis needs to be done in order to get a holistic picture of the complete process.

4.1 Proposed Work

1) It has been proposed to use Wavelet Transform for implementing OFDM.
2) Channels on which the system is to be simulated will be AWGN and Rayleigh Fading Channel.
3) To perform a comparative analysis of the OFDM based on wavelets , FFT and DCT.

5. Conclusion

In this review paper a comprehensive study about OFDM systems is undertaken. Special emphasis has been given on the implementation of OFDM.. Thus this paper summarizes various implementation techniques by which OFDM has been implemented in the pat. Also a future research work has been proposed which could help the research scholars to undertake the problem in a more holistic approach.

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