INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN 2278 – 0211 (Online)

Simulation of Models and BER Performances of DWT-OFDM versus DAUBECHIES-OFDM

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***Abstract**: OFDM technique is widely used due to its high spectrum efficiency. Fast Fourier Transforms (FFT) has been used to generate the orthogonal sub-carriers. Implementation complexity of FFT based OFDM, has led to replace conventional FFT based OFDM by wavelet based OFDM. The main objective of this paper is to replace the conventional FFT based OFDM system with some orthonormal wavelets. Comparing with the conventional OFDM, it is found that the Haar and Daubechies-based orthonormal wavelets are capable of reconstructing the transmitted symbol at the receiver side and effect of noise is reduced using wavelet denoising for different SNRs on AWGN channel. In this paper, results are tabulated for transmitted symbols and reconstructed symbols after wavelet denoising & compared for an analysis. The scatterplot analysis of DWT-OFDM is also presented for different SNRs.*

***Keywords**: OFDM, Haar Wavelet, Daubechies Wavelet, BPSK, BER, PAPR*

1. Introduction

OFDM system is one of the most promising technologies for current and future 4G wireless communications [1]. It is a multi-carrier transmission technique [2], which divides the available spectrum into many carriers, each one being modulated by a low rate data stream. Conventional OFDM system used IFFT and FFT to multiplex the signals in parallel with reduced complexity algorithm at the transmitter and receiver respectively. Many researchers have investigated the use of wavelet based to replace Fourier based OFDM and found out that the wavelet based has more advantages than Fourier based OFDM [3]-[6]. In paper [3], descriptions of Fourier based OFDM and Wavelet based OFDM and differences between them over the AWGN channel and Rayleigh channel presented. In paper [7], scatter plot analysis of wavelet OFDM is presented and symbol reconstruction is shown. In this paper, wavelet denoising applied on received symbols on AWGN channel. The transmitted and received symbols are presented for comparison. The results reveal that The DWT OFDM has potential to produce hardware complexity because it doesn't need a Cyclic Prefix and proposed system gives nearly perfect reconstruction. The paper is organized as follows: The system model is described in Section II. Simulation and results are discussed in Section III. Concluding remarks appear in Section IV**.**

2. System Model

The Following Diagram Shows DWT Based OFDM Transceiver

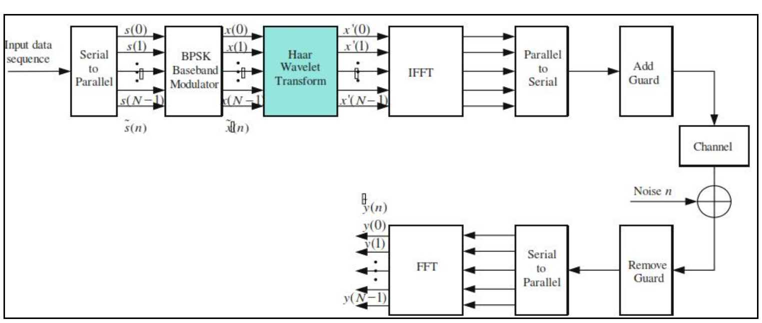

Figure 1: OFDM-DWT Transceiver

2.1. Modulation and Demodulation

Modulation and Demodulation is done by using QAM The predefined Look-up-table is used for converting bits into complex signal which are used to represent the QAM constellation points. The system is designed and simulated in MATLAB for 16QAM, 64QAM and 256QAM using MATLAB

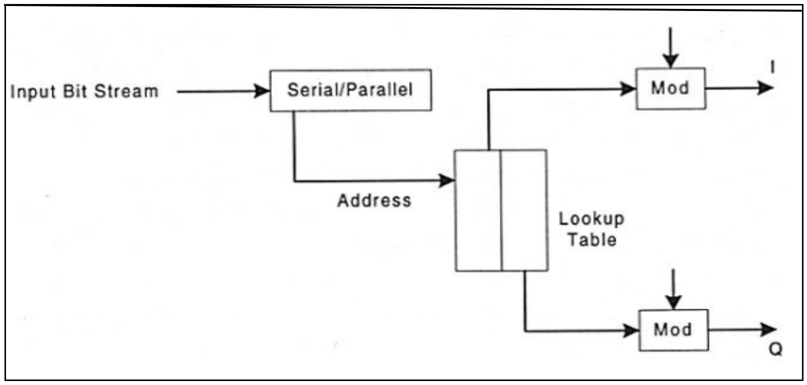

Figure 2: QAM Mapping

The constellation points are generated in such a way that, there should be a 1-Bit difference between two constellation points. The co-ordinates of ith message point (ai,bi) are elements of L by L matrix as shown below.

$$(a_i, b_i) = \begin{bmatrix} (-L+1, L+1) & (-L+3, L-1) & \cdots & (L-1, L-1) \\ \vdots & & \ddots & \vdots \\ (-L+1, -L+1) & (-L+3, -L+1) & \cdots & (L-1, -L+1) \end{bmatrix}$$

2.2. IDWT-DWT

The DWT is just a sampled version of CWT. The signals are analyzed in CWT using a set of basis functions which relate to each other by simple scaling and translation. While in the case of DWT, a time-scale representation of the digital signal is obtained using digital filtering techniques. The DWT is computed by successive low pass and high pass filtering of the discrete time-domain signal as shown in fig.3

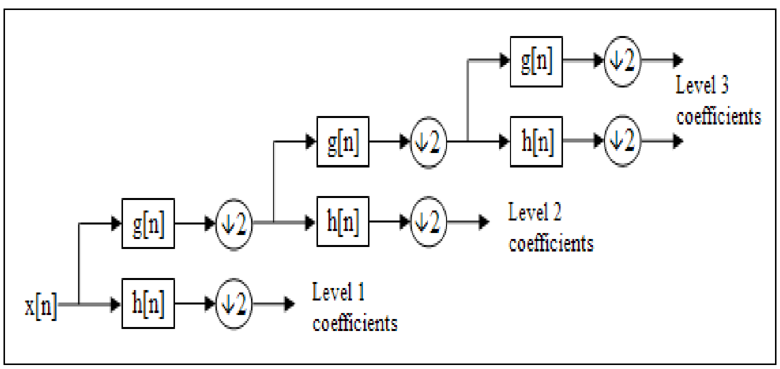

Figure 3: Structure of 3-Level wavelet decomposition

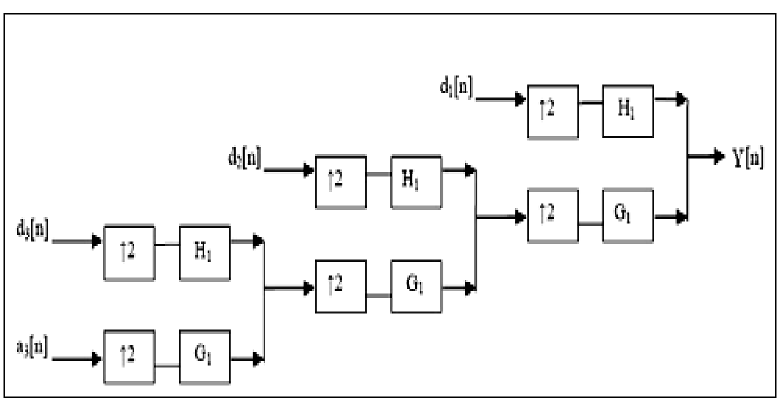

Figure 4: Three-level wavelet reconstruction

The proposed method is simulated using Haar wavelets for IDWT and DWT with 3 levels of decomposition and reconstruction.

2.3. AWGN Channel

Noise and interference are common transmission nuisances in wireless communication. Noise is modeled as Additive White Gaussian Noise (AWGN). In this channel, zero-mean white Gaussian noise is added to the transmitted signal x(t), so that the received signal r (t) can be represented as:

$$r(t) = x(t) + n(t) \quad \text{--------} \quad (3)$$

Where n (t) is a zero-mean Additive White Gaussian Noise process, with power spectral density N0/2.

2.4. Wavelet Denoising

The de-noising objective is to suppress the noise part of the signal r(t) and to recover x(t). The de-noising procedure proceeds in three steps:

- *Decomposition:* Choose a wavelet, and choose a level N. Compute the wavelet decomposition of the signals at level N.
- *Detail coefficients thresholding:* For each level from 1 to N, select a threshold and apply soft thresholding to the detail coefficients.
- *Reconstruction:* Compute wavelet reconstruction based on the original approximation coefficients of level N and the modified detail coefficients of levels from 1 to N.

3. Simulation & Discussion

Simulation has been carried out to transmit symbols over wavelet based OFDM system over AWGN channels. The transmitted symbols for different SNR are examined for AWGN channel. For performing the simulations, the flow chain shown in the Figure 1 is developed under a MATLAB 7.9.0 environment. The blocks are implemented by MATLAB instructions. The following is an overview of procedures

3.1. Transmitter

Input signal: PN Sequence (L=210 – 1 =1023Bits) Bit pattern Generation: Serial Bits is Converted into 4, 6 or 8 Bit Pattern Suitable for 16, 64 or 256QAM Generating Look-up table: Look-up table contains complex values corresponding to a bit pattern. QAM Encoder (16QAM, 64QAM, 256QAM): QAM constellation points are obtained by LUT method. IDWT: Wavelet Decomposition using Haar Wavelets. Time Domain conversion: Frequency domain signal is converted to time domain using IDWT and extract Real time signal.

3.2. Channel

Channel Estimation: Finding AWGN channel Transfer Function (TF). Convolving Received signal from Transmitter with Channel TF [Y = X * h]. Adding Noise to the Resulting signal [Y = X h + n].

3.3. Receiver

Wavelet Denoising: Noise Cancellation of received signal from channel is done by wavelet filters. De-Convolution [X=Y H T] Applying DWT: Wavelet Reconstruction using Haar Wavelets.

- *Applying DWT:* Wavelet Reconstruction using Haar Wavelets.
- *QAM Decoder:* Symbols are compared with desired Lookup table, produces corresponding complex signal. The table 1 below shows difference between Denoised signal and the Transmitted signal for SNR=22dB for first 8symbols.

3.4. Figures and Tables

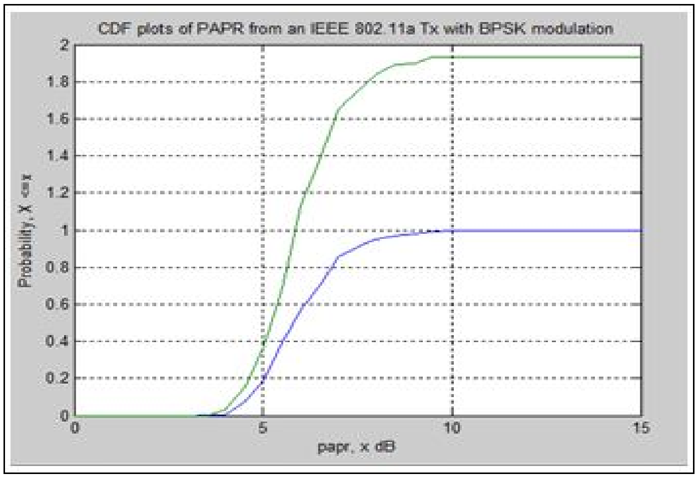

Figure 5: PAPR performance of Haar based OFDM versus Daubechies OFDM system

Figure5 shows the cumulative distribution functions of the PAPR, determined empirically over one million OFDM symbols. The proposed OFDM improves the PAPR statistics of OFDM. When the probability of input symbol '1' or '0' is 0.5, the proposed OFDM approximately has the same cumulative distribution functions as the conventional OFDM. When the probability of input symbol '1' or '0' larger than 0.6, the proposed OFDM almost has the PAPR reduced by 3 dB approximately, which is agree with our theory analysis.

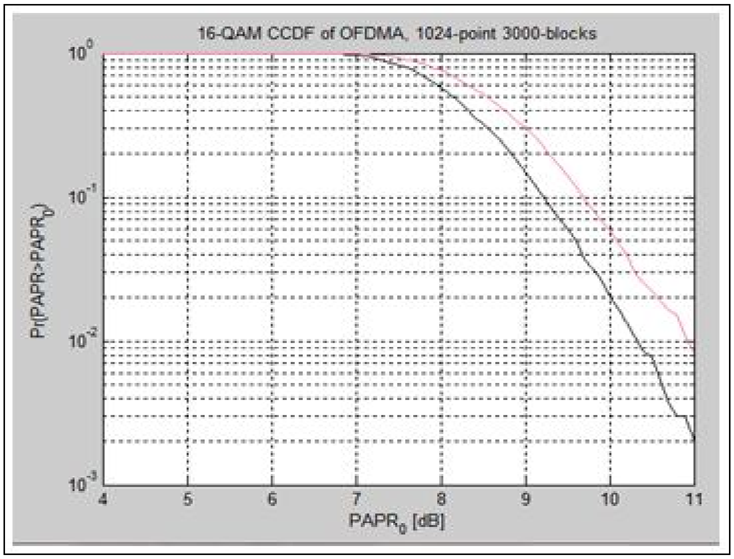

Figure 6: BER performance of Haar based OFDM system versus Daubechies based OFDM system

For simplicity, we assume that the maximum-likelihood (ML) estimation method is used at the receiver, although the BER performance in theory is based on Costas loop demodulation.

From Fig 6, one can clearly see the improvement of the proposed OFDM system performance. Since the nonspectral-null property of Channel B is better than that of Channel A, one can see that the BER performances of all the OFDM systems in Fig.6 for Channel B are better . The spectral-null property of Channel A and Channel B makes the conventional OFDM system performs poorly. One can also see that the proposed OFDM system can improve the BER performance 3 dB at most. Hence, our proposed OFDM system shows robustness to spectral-null channel compared with the conventional OFDM system, which is very preferable in practical applications.

4. Conclusions

Simulation approaches using MATLAB for wavelet based OFDM, particularly in DWTOFDM as alternative substitutions for Fourier Based OFDM are presented. Conventional OFDM systems use IFFT And FFT algorithms at the transmitter and receiver respectively to multiplex the signals and transmit them simultaneously over a number of subcarriers. The system employs guard intervals or cyclic prefixes so that the delay spread of the channel becomes longer than the channel impulse response. The System must make sure that the cyclic prefix is a small fraction of the per carrier symbol duration. The Purpose of employing the CP is to minimize inter-symbol interference (ISI). However a CP reduces the power Efficiency and data throughput. The CP Also has the disadvantage of reducing the spectral Containment of the channels. Due To these issues, an alternative method is to use the wavelet Transform to replace the IFFT And FFT blocks. The Wavelet transform is referred as Discrete Wavelet Transform OFDM (DWT-OFDM). By using the transform, the spectral containment of the channels is better since they are not using CP. The wavelet based OFDM (DWTOFDM) Is assumed to have orthonormal bases properties and satisfy the perfect reconstruction property. We use Different wavelet families particularly, Biorthogonal And Daubechies And compare with conventional FFT-OFDM system. BER performances of both OFDM Systems are also obtained. It Is found that the DWT-OFDM platform is superior as compared to others as it has less error rate, especially using bior5.5 wavelet family.

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