Performance Evaluation of DWT Based OFDM Using Different Modulation Techniques

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Abstract- Orthogonal frequency division multiplexing (OFDM) is a kind of multicarrier modulation scheme in which available bandwidth is divided into narrow bands at different frequencies. It is capable of compressing a large amount of data into a small amount of bandwidth. This could be made possible by dividing a large amount of data into smaller parts, then sending that data concurrently over a number of frequencies. Moreover, OFDM allows a large amount of data to be transmitted rapidly and reliably with a minimum of loss or interference. As OFDM finds various applications in the field of communication like Wi-Fi, 4G, DAB & WiMax. The conventional OFDM systems uses IFFT and FFT at the transmitter and receiver respectively but DWT-OFDM is emerged as an alternative approach to the existing conventional FFT based OFDM system. The BER performance of the OFDM system has been significantly improved by achieving BER of 10^{-4} at 6db SNR when DWT is used in place of conventional FFT method. Afterwards, all the wavelets were compared to find the optimum wavelet among all. The results achieved had shown that the wavelet 'Symlet5' outperformed all the other wavelets as well as FFT-OFDM system.

Keywords- Wi-Fi, 4G, WiMax, OFDM, IFFT and FFT.

I. INTRODUCTION

With the ever growing demand of this generation, there is a need for high speed communication to be developed. Several multicarrier modulation techniques have been developed in order to meet these demands, few notable among them are Code Division Multiple Access (CDMA) and Orthogonal Frequency Division Multiplexing (OFDM). Orthogonal Frequency Division Multiplexing can be defined as frequency-division multiplexing (FDM) scheme utilized as a digital multi-carrier modulation method. In OFDM multiple subcarriers having some orthogonality among them are used to carry data. The data is divided into several parallel streams of data. Each sub-carrier is modulated with a modulation scheme (such as BPSK) at a low symbol rate, so total data rates becomes similar to the conventional single carrier modulation schemes in the same bandwidth. The performance of high data rates communication systems is limited by frequency selective multipath fading. Since selective fading causes inter-symbol-interference. In the wireless channels impairments such as fading of signals, shadowing and symbol interferences occur due to multiple user access degrade the system performance. Multicarrier modulation (MCM) has been proved to be the solution that overcomes these problems in wireless channels. It is the technique of transmitting data and further dividing the serial data streams into a multiple numbers of low data rate parallel streams [1]. Orthogonal Frequency Division Multiplexing (OFDM) is a sort of multi-carrier modulation, which divides the available spectrum among multiple parallel subcarriers and each subcarrier is further modulated by a parallel data stream at different carrier frequency. The conventional OFDM system makes use of IFFT and FFT for multiplexing of signals and reduces the system complexity at both transmitter and receiver [2].

Orthogonal Frequency Division Multiplexing (OFDM)

In early nineties orthogonal frequency division multiplexing was proposed to solve the problem of bandwidth inefficiency. The attractive feature of OFDM is that, it uses different sub-carriers which are orthogonal to each other. Since OFDM allows overlapping sub-channels in the frequency domain, thus increases the transmission rate up to Gbps. This carrier spacing provides optimal spectral efficiency. Nowadays, OFDM has grown to be the most popular communication system in high-speed communications. OFDM is becoming the selected modulation technique for wireless communications. OFDM is capable of providing large data rates with sufficient robustness to radio channel impairments. OFDM is a combination of modulation and multiplexing.

Cyclic Prefix

The Cyclic Prefix is a periodic addition of the last part of an OFDM symbol that is affixed to the front of the symbol in the transmitter, and at the receiver side it is removed before demodulation [1].

The cyclic prefix is advantageous as –

- The cyclic prefix acts as a guard band.
- It minimizes the inter-symbol interference caused due to the previous symbol.
- It acts as a repetition of the end of the symbol thus allow a frequency-selective channel to be modeled analogous to circular convolution which in turn maybe transformed to the frequency domain using a Fourier transform.

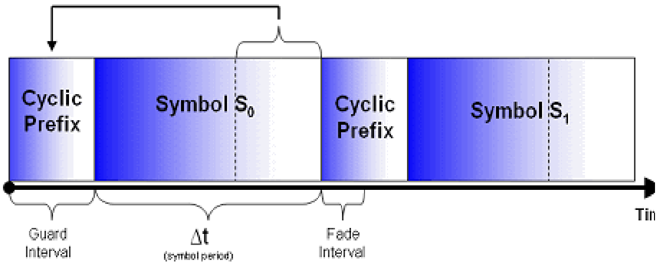

Fig.1: Cyclic Prefix

II. PROPOSED METHODOLOGY

The conventional OFDM system makes use of IFFT and FFT in the transmitter and receiver respectively but it has some drawbacks.

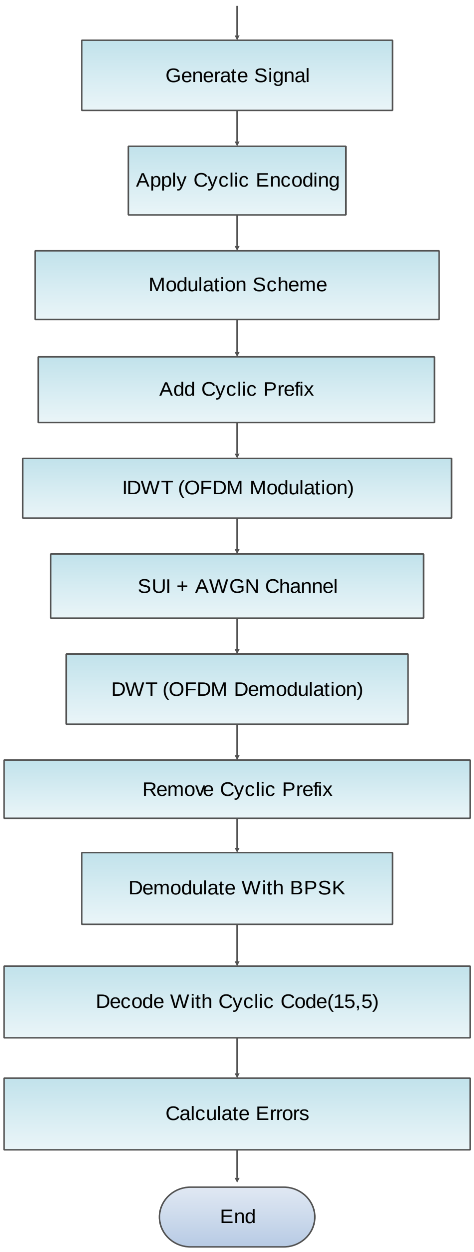

Fig.2: flow chart of Proposed Methodology

OFDM provides an efficient means to reduce the inter-symbol interference with the use of cyclic prefix but CP has the drawback of reducing the spectral efficiency of the channels. To overcome these drawbacks, DWT-OFDM is used as an alternative method. Cyclic prefix is not required in DWT-OFDM systems as wavelets possess ortho-normal nature, thus satisfy the perfect reconstruction property. Conventional OFDM has been replaced by DWT based OFDM and BER performance of wavelets has been evaluated using different modulation techniques such as 4 QAM, 8 QAM, 16 QAM, BPSK etc.

The aim is to achieve best possible performance with minimum SNR. Mainly 'Symlet5' and 'Coiflet1' has been employed for BER comparison. The entire process can be explained with the help of a flow chart.

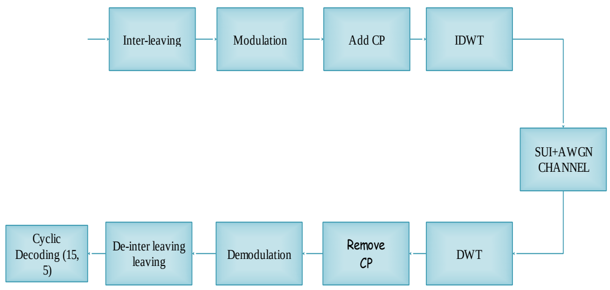

Fig.3: Simulated Wavelet Based OFDM System

III. SIMULATION & RESULT

Simulation is carried out for DWT-OFDM system. The study and comparisons are based on simulation done using MATLAB. The BER performance as a function of SNR is examined for SUI channel and the results are plotted as reported in figures given below. Simulation has been carried out using wavelet based OFDM using 4-QAM scheme. Symlet5 and Coiflet1 wavelets have been used from existing 'haar' and 'dB2' wavelets. Since 'Coiflets' family consists of compactly supported wavelets with highest number of vanishing moments for both ψ and φ while 'Symlets' wavelets are compactly supported wavelets which is having least asymmetry.

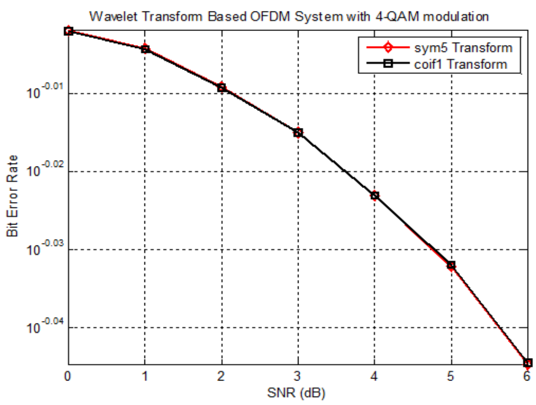

Fig.4: BER Comparison with 4-QAM in SUI channel

it is shown in fig.4 That ‘Symlet5’ and ‘Coiflet1’ are having almost similar performances in the SNR range from 0 to 6 dB Both the wavelets have successfully achieved BER of $10^{-0.05}$ at 6db SNR.

In fig.5 Simulation has been carried out using DWT based OFDM using 8-QAM modulation technique. It is shown in fig.5. That ‘Symlet5’ and ‘Coiflet1’ are having almost similar performances in the SNR range from 0 to 6 dB. There is linear relationship between SNR and BER. Both the wavelets have successfully achieved BER of $10^{-0.15}$ at 6dB SNR.

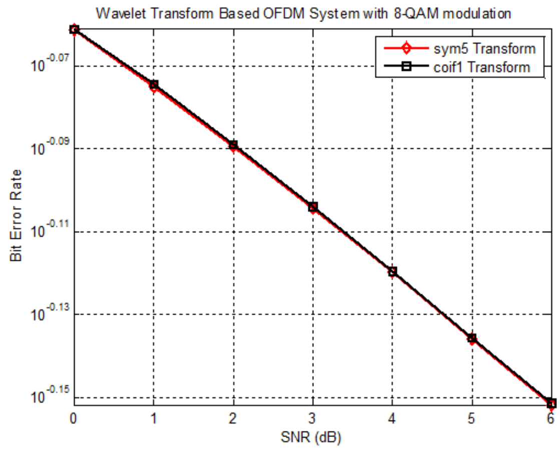

Fig.5: BER Comparison with 8-QAM in SUI channel

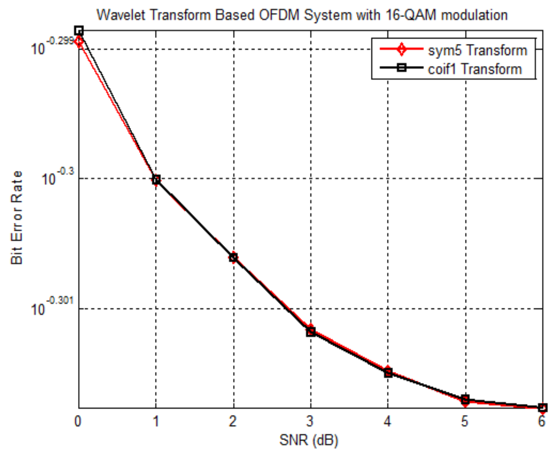

Fig.6: BER Comparison with 16-QAM in SUI channel

In fig.6 Simulation has been carried out in DWT based OFDM using 16-QAM modulation scheme. It can be observed from fig.6 that ‘Symlet5’ and ‘Coiflet1’ are having almost similar performances in the SNR range from 1 to 6 db. There is improvement in performances both the wavelets have successfully achieved BER of While in the SNR range 0 to 1db ‘Symlet5’ wavelet outperforms the ‘Coiflet’ wavelet by achieving $10^{-0.299}$ BER at 0 dB SNR. $10^{-0.302}$ at 6db SNR from existing $2{\times}10^{-1}$ BER at 6db with ‘haar’ and ‘db2’ wavelet.

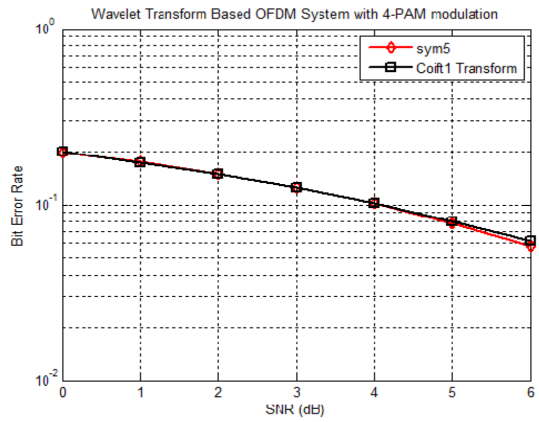

Fig.7: BER Comparison with 4-PAM in SUI channel.

In fig.7 Simulation has been carried out in DWT based OFDM using 4-PAM modulation scheme. It can be observed from fig.7 That ‘Symlet5’ and ‘Coiflet1’ are having almost similar performances in the SNR range from 1 to 6 db. While in the SNR range 0 to 1db ‘Symlet5’ wavelet outperforms the ‘Coiflet’ wavelet by achieving $10^{-0.299}$ BER at 0 db SNR.There is improvement in performanceas both the wavelets have successfully achieved BER of $10^{-0.302}$ at 6db SNR from existing 2×10^{-1} BER at 6db with ‘haar’ and ‘db2’ wavelet.

In fig.8 Simulation has been carried out in DWT based OFDM using BPSK modulation scheme. It can be observed from fig.8 That ‘Coiflet1’ outperforms ‘Symlet5’ in the SNR raging 0 to 3db, while in the SNR range from 3 to 6db ‘Symlet5’ outperforms ‘Coiflet1’ by achieving BER 10^{-4} at 6db SNR. There is a significant improvement in BER performance as the ‘Symlet5’ have successfully achieved BER of 10^{-4} at 6db SNR from existing BER 10^{-3} at 6db with ‘haar’ and ‘db2’ wavelet.

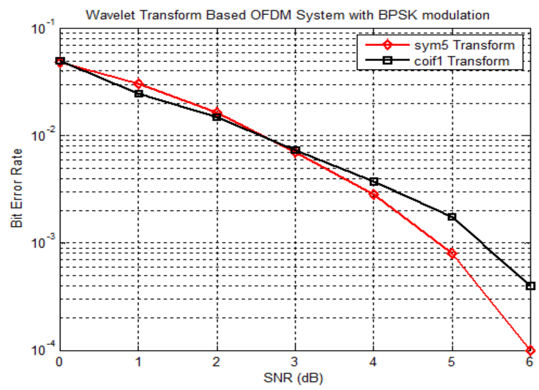

Fig.8: BER Comparison with BPSK in SUI channel

IV.CONCLUSION & FUTURE SCOPE

MATLAB simulation for the DWT-OFDM system with cyclic encoding is presented for SUI channel using different modulation schemes. It can be concluded that

BPSK outperforms all the other modulation schemes by achieving least BER of 10^{-4} with ''Symlet5'' at 6 db SNR. Moreover, Using Cyclic codes in DWT based OFDM, the BER of 10^{-3} is obtained at SNR of 5 dB in SUI channel whereas the same value of BER is achieved at 6 dB of DWT based OFDM system without encoding. Thus, an improvement of 1 dB has been achieved and 'symlet5' outperforms all the other wavelets. Moreover, the BER performance of the system is affected by the outage probability. Outage probability is the probability when the required data rate is not supported by the specific channel due to variable SNR .The Cyclic encoding coupled with bit interleaving reduces the outage probability at higher SNR. Thus, the DWT-OFDM system with encoding outperforms at higher values of SNR. Finally it is important to emphasize that wavelet theory is still developing .It is expected that more is still to be explored out as the knowledge of this recently proposed scheme gains more interest .There are many possibilities for future work in this area.

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