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Improving BER Performance of HAAR and Le-Gall Wavelet Based OFDM

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ABSTRACT

Transform of the signal is just another form of representing the signal. In Fourier theory a signal can be represented as the sum of a possibly infinite series of sinusoids, which is referred to as a Fourier expansion. Fourier expansion works well with time invariant signals. For a time-varying signal, a complete characterization in the frequency domain should include the time aspect, resulting in the time-frequency analysis of a signal. The wavelet transform provides the time-frequency representation of the signal. In this simulation results for FFT and Wavelet based filter on OFDM technique is discussed. The wavelets used in the works are Haar and Le-Gall. Finally it is shown that Le-Gall wavelet gives better result than Haar and FFT in term of Bit Error Rate (BER).

Keywords:— *Orthogonal frequency division multiplexing (OFDM), Bit Error Rate (BER), Le-Gall wavelet, Haar wavelet.*

I. INTRODUCTION

Orthogonal frequency division multiplexing (OFDM) is a modulation technique which allocates orthogonal sub carriers. It is a multi carrier transmission where the single data stream is transmitted over a number of low rate subcarriers. [1]

OFDM is thus combination of both modulation and multiplexing. Independent signals are the sub-set of main signal are multiplexed in OFDM and also the signal itself is first split into independent channels, modulated by data and then re-multiplexed to create OFDM carrier. OFDM has a property that allows simultaneous transmission of additional sub-carriers in a tight frequency space without interference from each other. In OFDM system, orthogonality of subcarrier is the main concept. Normally OFDM is implemented using FFT and IFFT's. [2]

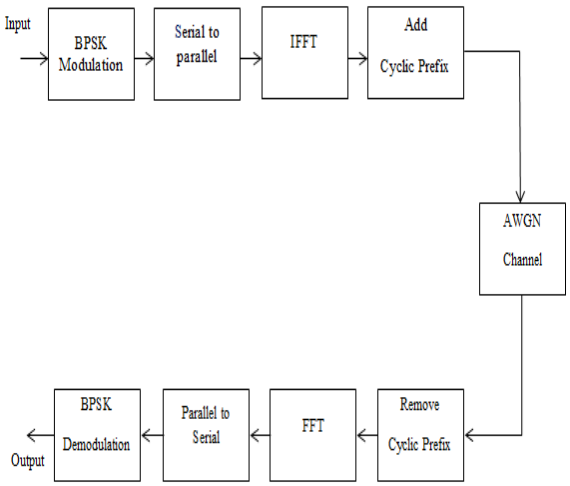

Figure 1: FFT-Based OFDM System [2]

In OFDM technique, Fourier transform perform the base band modulation and demodulation as the use of this transform

increased the efficiency of the modulation and demodulation processing. The use of the guard space solves the problems of ISI to a greater extent. Although the system envisioned as such did not attain the perfect orthogonality between subcarriers in a time dispersive channel, nonetheless it was a major contribution to the evolution of OFDM system.

In quest of solving the problem of orthogonality over the dispersive channel, cyclic prefix (CP) is introduced. It fills the guard space with the cyclic extension of the OFDM symbol. Although addition of the cyclic prefix causes a reduction of the data rate, this deficiency was more than compensated by the ease of receiver implementation [3].

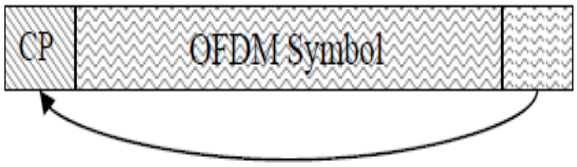

Figure 2: Cyclic Prefix in OFDM symbol [6]

OFDM is used in physical layer of different wireless standards like IEEE 802.11a, IEEE 802.16a and HIPERLAN/2. All this schemes use discrete Fourier transform to generate orthogonal subcarriers [1].

II. Wavelet Transform

Wavelet transform is used to analyze signals by the coefficients of wavelets in both time as well as in frequency domain. Here elementary waveforms are not sinc and cosine waveforms like in Fourier transform. ISI and ICI are caused by loss of orthogonality between carriers caused by multipath propagation of the signal in Discrete Fourier Transform (DFT) based OFDM. ISI is between successive symbols of same subcarrier and ICI is among different signals at different subcarriers. Both ISI and ICI are avoided by using cyclic prefix which causes bandwidth inefficiency and power loss in DFT based OFDM [4].

Wavelet transforms (DWT and IDWT) is an alternative platform for replacing IFFT and FFT. By using this transform, spectral containment of channels was good since it does not use cyclic prefix. One type of wavelet transform is Discrete Wavelet Transform OFDM (DWT-OFDM). It employs High Pass Filter (HPF) and Low Pass Filter (LPF) operating as quadrature Mirror Filters satisfying orthonormal bases properties and perfect reconstruction. The transform uses filter coefficients as approximate and detail in HPF and LPF respectively. The approximated coefficient is referred as scaling coefficient, whereas the detailed coefficient is referred as wavelet coefficient [5].

In discrete wavelet transform (DWT), input signal will pass through several different filters and decomposed into high pass and low pass bands through the filters. During decomposition high pass filter will remove frequencies below half of the highest frequency and low pass filter will remove frequencies that are above half of highest frequency. The decomposition halves the time resolution because half of the samples are used to characterize the signal similarly frequency resolution will be doubled and this decomposition process will be repeated again for obtaining wavelet coefficients of required level. Two types of coefficients are obtained through this processing, first are called detailed coefficients obtained through high pass filter and second are called coarse approximations obtained low pass filter related with scaling process. After passing the data through filters the decimation process will performed. The whole procedure will continue till the required level is obtained [4].

The properties of wavelets make it as a better choice for different applications like biomedical engineering, nuclear engineering, pure mathematics, computer graphics and animation, acoustics and seismology, image synthesis, magnetic resonance imaging, data

compression, astronomy, music, optics, human vision, radar etc [3].

In this paper, wavelet based OFDM is implemented. The wavelet used are Haar and Le-Gall and comparision is done with FFT based OFDM.

III. RESULT

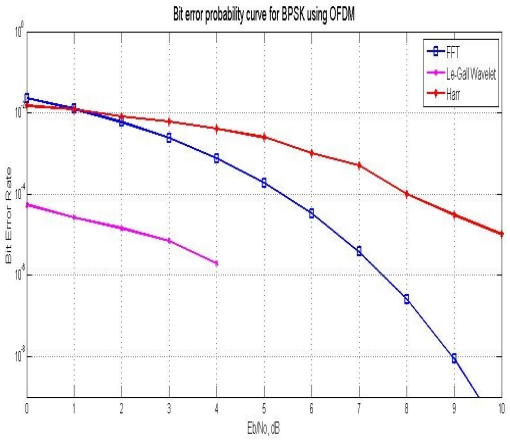

Figure 3: Bit error probability is presented for BPSK using OFDM with FFT, Haar and Le-Gall wavelets.

In Figure 3, Bit error probability is presented for BPSK using OFDM with FFT, Haar and Le -Gall wavelets. BER performance of the Haar wavelet is slightly better than the FFT. The performance of Le-Gall wavelet is much better than the Haar and FFT.

IV. CONCLUSION

In this paper OFDM technique is detailed with wavelet. It is concluded that wavelet based OFDM system performs better than the FFT based system and Haar wavelet is inferior to Le-Gall wavelet.

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