Performance Analysis for OFDM System Using Fourier Transform and Wavelet Transform with Different Modulation Techniques

Qusay jalil, S Nagakishore Bhavanam

Abstract— In OFDM multiple carriers are used and it provides higher level of spectral efficiency as compared to Frequency Division Multiplexing (FDM). In OFDM because of loss of orthogonality between the subcarriers there is inter carrier interference (ICI) and inter symbol interference (ISI) and to overcome this problem use of cyclic prefixing (CP) is required, which uses 20% of available bandwidth. Comparison between the conventional FFT based OFDM systems with DWT based OFDM system have been made according to some conventional and non-conventional modulation methods over AWGN. The wavelet families have been used and compared with FFT based OFDM system and found that DWT based OFDM system is better than FFT based OFDM system with regards to the bit error rate (BER) performance.

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Index Terms— OFDM; FFT; DWT Families [Haar; DB; Biorthogonal]; BER; SNR; LTE

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1 INTRODUCTION

OFDM is a wideband wireless digital communication technique that is based on block modulation. With the wireless multimedia applications becoming more and more popular, the required bit rates are achieved due to OFDM multicarrier transmissions. Multicarrier modulation.

is commonly employed to combat channel distortion and improve the spectral efficiency. Multicarrier Modulation schemes divide the input data into bands upon which modulation is performed and multiplexed into the channel at different carrier frequencies so that information is transmitted on each of the sub carriers, such that the sub channels are nearly distortion less. In conventional OFDM system, IFFT (Inverse Fast Fourier Transform) and FFT [9] (Fast Fourier Transform) are used to multiplex the signals together and decode the signal at the receiver respectively. In this system, the Cyclic Prefix is added before transmitting the signal to channel. But in wavelet based transmission technique has stronger ability of suppressing ISI and ICI than the conventional OFDM scheme. Two types of modulation schemes are used in this paper which is Conventional and non-convention modulation schemes. BPSK, QPSK and QAM are the parts of conventional modulation schemes whereas Differential BPSK and Differential QPSK are the non-conventional modulation schemes. BPSK is the one of the simplest forms of digital modulation.

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The phase of the constant amplitude carrier signal moves between zero and 180 degree.

Differential PSK is a non coherent form of phase shift keying which avoids the need for a coherent reference signal at receiver. The non coherent receivers are easy and cheap to build, and hence are widely used in wireless communications [4]. The QPSK is a multilevel modulation technique; it uses 2 bits per symbol to represent each phase. Compared to BPSK, it is more spectrally efficient but requires more complex receiver. In differentially-encoded QPSK (DQPSK), the phase-shifts are 0°, 90°, 180°, -90° corresponding to data '00', '01', '11', '10'. This kind of encoding may be demodulated in the same way as for non-differential PSK but the phase ambiguities can be ignored. QAM is the method of combining two amplitude modulated signals into one channel. It may be an analogy QAM or a digital QAM. Analogy QAM combines two amplitude modulated signals using the same carrier frequency with a 90 degree phase difference. Adaptive channel equalizers utilize channel estimates to overcome the effects of inter symbol interference. Diversity techniques utilize the channel estimate to implement a matched filter such that the receiver is optimally matched to the received signal instead of the transmitted one. Maximum likelihood detectors utilize channel estimates to minimize the error probability. One of the most important benefits of channel estimation is that it allows the implementation of coherent demodulation. Coherent demodulation requires the knowledge of the phase of the signal. This can be accomplished by using channel estimation techniques. In this paper channel impulse response has been estimated and compared using LS, MMSE and DFT /DWT based estimation techniques. The paper is organized as follows. In Section 2, MIMO system and channel estimation is described. Section 3 discusses training DFT/DWT based channel estimation. Simulation and results for the performance of BPSK, QPSK, and QAM, LS, MMSE and DFT/DWT based techniques are given in section 4 and Section 5 concludes the paper

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2 MIMO System:-

Detailed submission MIMO communication uses multiple antennas at both the transmitter and receiver to exploit the spatial domain for spatial multiplexing and/or spatial diversity. Spatial multiplexing has been generally used to increase the capacity of a MIMO link by transmitting independent data streams in the same time slot and frequency band simultaneously from each transmit antenna, and differentiating multiple data streams at the receiver using channel information about each propagation path.

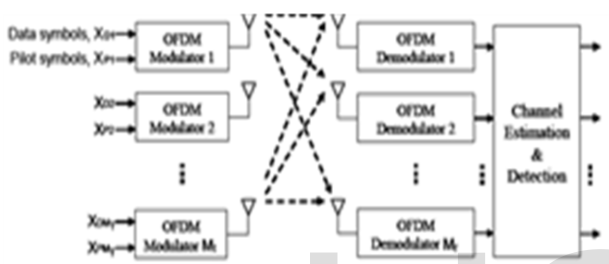

Fig. 1.. MIMO System Process

In MIMO-OFDM systems, channel state information (CSI) is essential at the receiver in order to coherently detect the received signal and to perform diversity combining or spatial interference suppression. The channel is very important to the performance of diversity schemes, and more variable channels give more diversity. Thus, in order to attain accurate CSI at the receiver, pilot-symbol-aided or decision-directed channel estimation must be used to track the variations of the frequency selective fading channel. Among the various resources in MIMO multicarrier systems the power assignment is related to the accuracy of the channel estimation.

3 Fourier Transform Based Channel Estimation

DFT can be used simultaneously as an accurate interpolation method in the frequency domain when the orthogonality between training sequences is based on the transmission of scattered pilots.

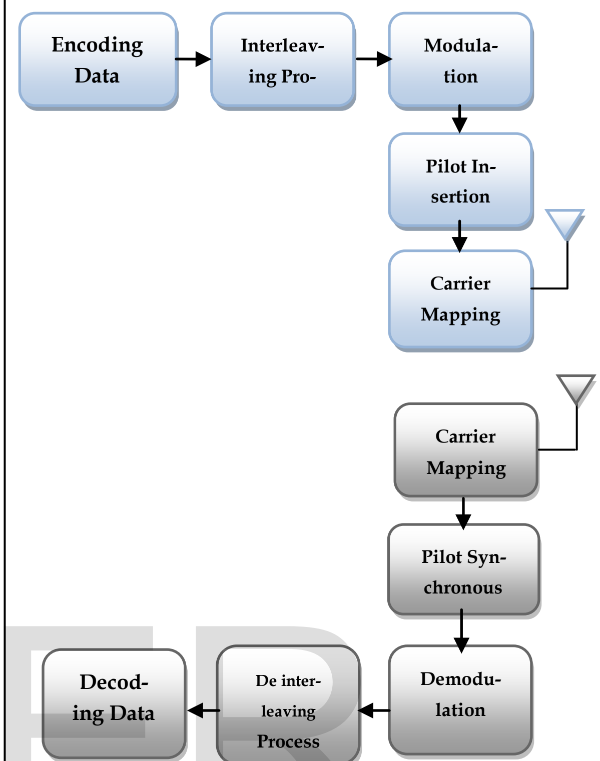

Fig. 2.. Block Diagram: FFT Based OFDM

In received signal constellation before and after channel compensation for the OFDM system with 16-QAM, illustrating the effect of channel estimation and compensation Here; illustrates the channel estimates obtained by using LS- linear, LS-spine and MMSE channel estimation methods with and without DFT technique and reveals that the DFT-based channel estimation method improves the performance of channel estimation

4 Wavelet Based Channel Estimation:-

A wavelet is a small piece of a wave. Where a sinusoidal wave as is used by Fourier transforms carries on repeating itself for infinity, a wavelet exists only within a finite domain, and is zero-valued elsewhere.

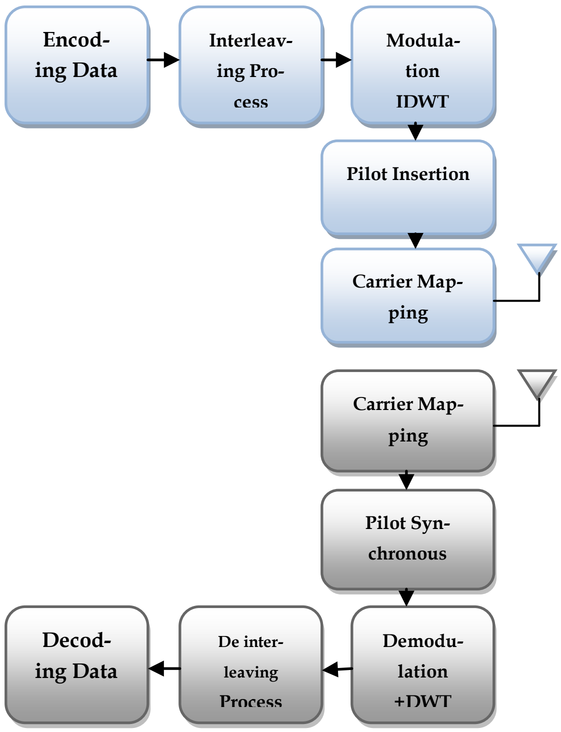

Fig. 3.. Fig: Block Diagram: DWT Based OFDM

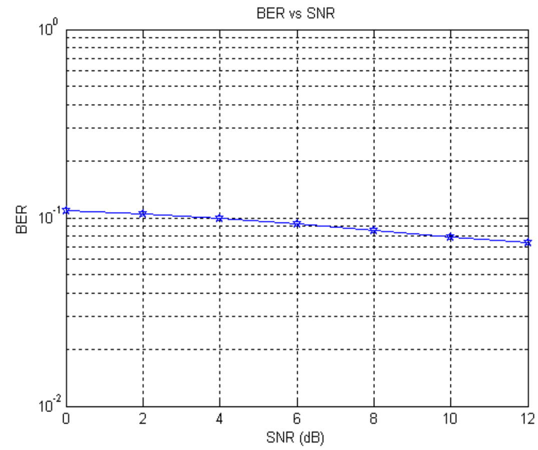

Fig.4..16QAM Modulation on HAAR Transform on OFDM Channel

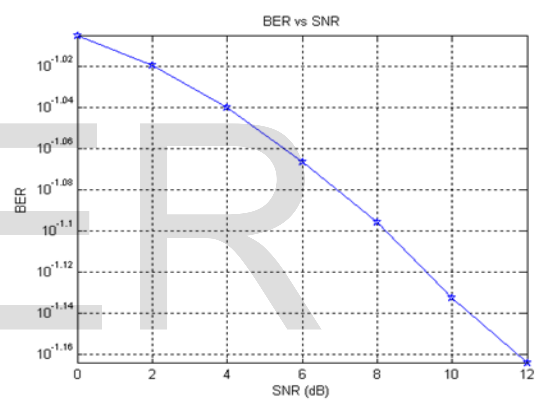

Fig.5..64QAM Modulation on HAAR Transform on OFDM Channel

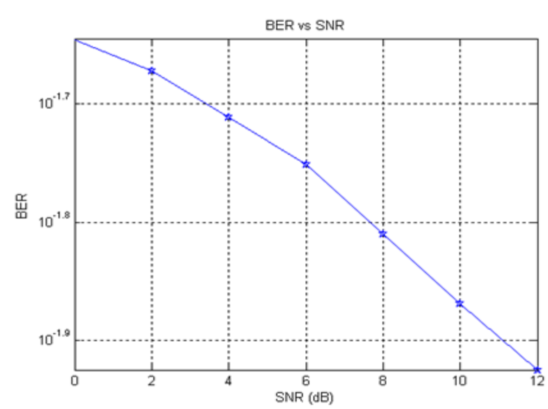

Fig.6..256QAM Modulation on HAAR Transform on OFDM Channel

A wavelet transform involves convolving the signal against particular instances of the wavelet at various time scales and positions. Hence, wavelet transform as a joint time-frequency domain. The typical application fields of wavelets are like Astronomy, acoustics, nuclear engineering, sub-band coding, signal and image processing. There are some sample applications identifying pure frequencies, De-noising signals, Detecting discontinuities and breakdown points, Detecting self similarity and Compressing samples.

4.1 HAAR:-

For an input represented by a list of numbers, the HAAR wavelet transform may be considered to simply pair up input values, storing the difference and passing the sum. This process is repeated recursively, pairing up the sums to provide the next scale, finally resulting in differences and one final sum. The HAAR Wavelet Transformation is a simple form of compression which involves averaging and differencing terms, storing detail coefficients, eliminating data, and reconstructing the matrix such that the resulting matrix is similar to the initial matrix.

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4.2 Daubechies:-

Ingrid Daubechies, one of the brightest stars in the world of wavelet research, invented what are called compactly supported orthonormal wavelets -- thus making discrete wavelet analysis practicable. The names of the Daubechies family wavelets are written db N, where N is the order, and db the "surname" of the wavelet. The db1 wavelet, as mentioned above, is the same as HAAR wavelet. Here is the wavelet functions psi of the next nine members of the family**: DB2 ;DB3 ;DB4; DB5 ; DB6 ;DB7 ;DB8 ;DB9 ;DB10**

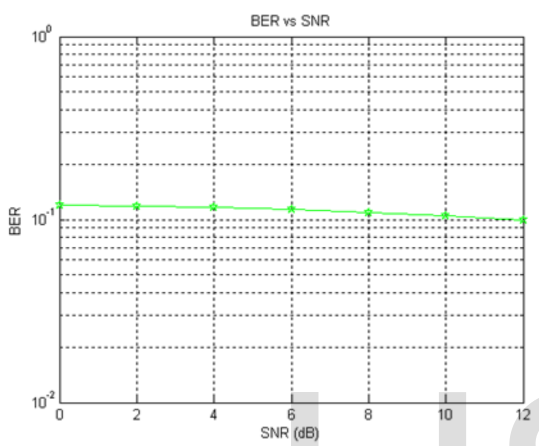

Fig7: 16QAM Modulation on Daubechies Transform on OFDM Channel

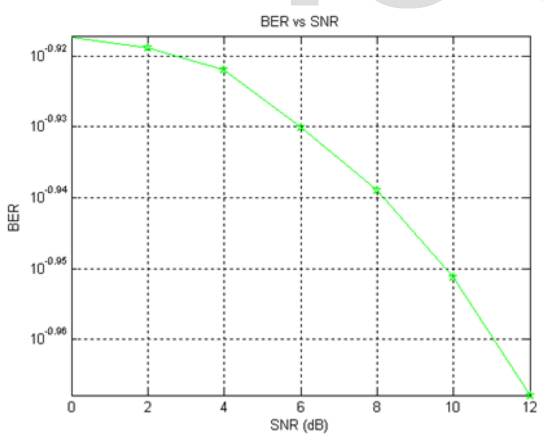

Fig8: 64QAM Modulation on Daubechies Transform on OFDM Channel

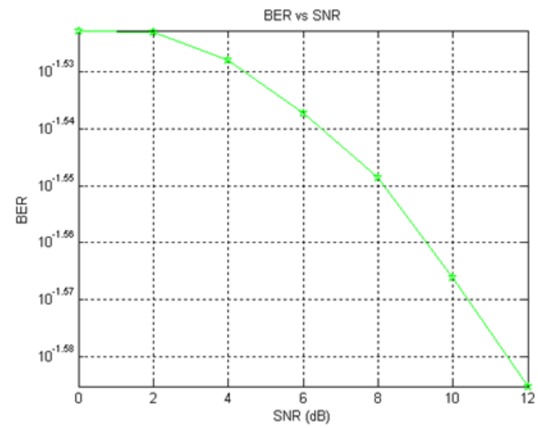

Fig9: 256QAM Modulation on Daubechies Transform on OFDM Channel

4.3 Biorthogonal:-

This family of wavelets exhibits the property of linear phase, which is needed for signal and image reconstruction. By using two wavelets, one for decomposition (on the left side) and the other for reconstruction (on the right side) instead of the same single one, interesting properties are derived. Bior1.3; Bior1.5; Bior2.2; Bior2.4; Bior2.6; Bior2.8; Bior3.1; Bior3.3; Bior3.5; Bior3.7; Bior3.9; Bior4.4; Bior5.5; Bior6.8

Step1: Column wise processing to get H and L
H = (Co-Ce) L = (Ce + H/2) Where Co and Ce is the odd column and even column wise pixel values

Step 2: Row wise processing to get LL,LH,HL and HH, Separate odd and even rows of H and L, Namely, Hodd – odd row of H, Lodd- odd row of L, Heven- even row of H Leven – even row of L

LH = Lodd-Leven LL = Leven + (LH / 2)

HL = Hodd – Heven HH = Heven + (HL /2)

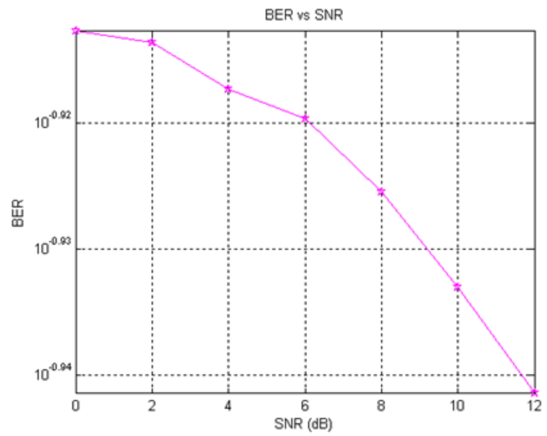

Fig10 :16QAM Modulation on Biorthogonal Transform on OFDM Channel

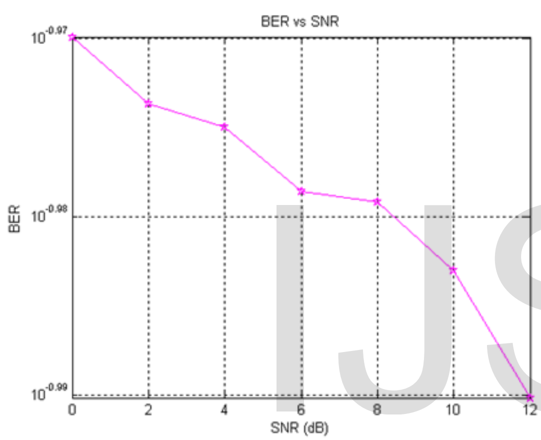

Fig11 :64QAM Modulation on Biorthogonal Transform on OFDM Channel

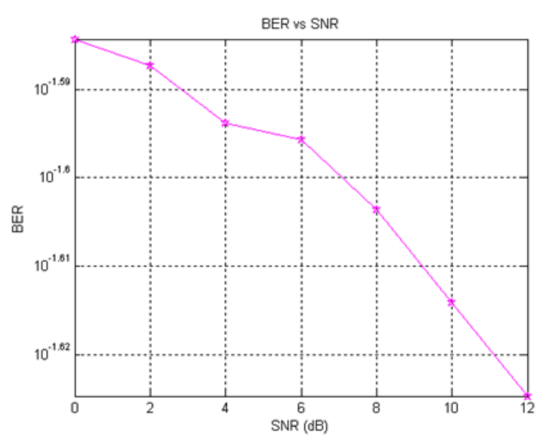

Fig12 :256QAM Modulation on Biorthogonal Transform on OFDM Channel

5 MODULATION:-

In modulation, a message signal, which contains the information, is used to control the parameters of a carrier signal, so as to impress the information onto the carrier. analogue – denoted by $m(t)$ digital – denoted by $d(t)$ – *i.e.* sequences of 1's and 0's The message signal could also be a multilevel signal, rather than binary; this is not considered further at this stage.

Tabl 1 :- symbol rate of different modulation techniques

MODULATION	Bits/Symbol	Symbol Rate
BPSK	2	1/2(0.5)
QPSK	4	1/4(0.25)
QAM-8	8	1/8(0.125)
QAM-16	16	1/16(0.0625)
QAM-64	64	1/64(0.015625)
QAM-256	256	1/256(0.00390625)

6 RESULT ANALYSIS:-

6.1 BER PERFORMANCE EVALUATION

By using MATLAB performance characteristic of DFT based OFDM and wavelet based OFDM are obtained for different modulations that are used for the LTE, as shown in figures. Modulations that could be used for LTE are QPSK, 16 QAM and 64 QAM (Uplink and downlink). QPSK does not carry data at very high speed. When signal to noise ratio is of good quality then only higher modulation techniques can be used. Lower forms of modulation (QPSK) does not require high signal to noise ratio. For the purpose of simulation, signal to noise ratio

(SNR) of different values are introduced through AWGN channel. Data of 9600 bits is sent in the form of 100 symbols, so one symbol is of 96 bits. Averaging for a particular value of SNR for all the symbols is done and BER is obtained and same process is repeated for all the values of SNR and final BERs are obtained. Firstly the performance of DFT based OFDM and wavelet based OFDM are obtained for different modulation techniques. Different wavelet types biorthogonal, daubechies2 and haar is used in wavelet based OFDM for 16-QAM, 64-QAM, 256QAM.

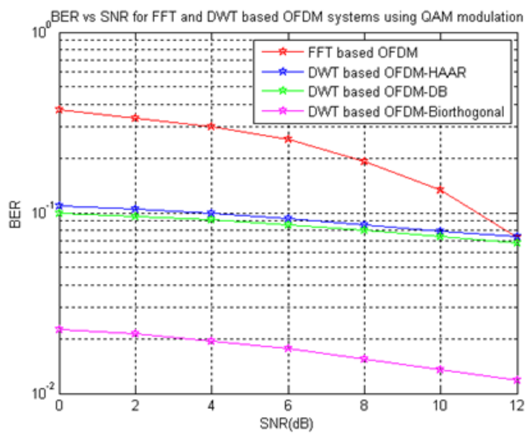

Fig13: Comparison Analysis of FFT vs. Wavelet for HAAR; DB; Biorthogonal Process Using 16QAM

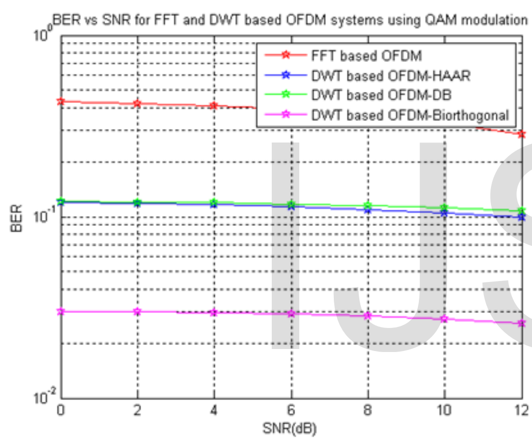

Fig14: Comparison Analysis of FFT vs. Wavelet for HAAR; DB; Biorthogonal Process Using 64QAM

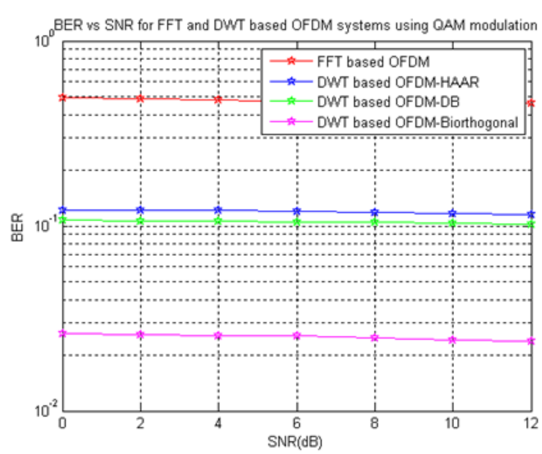

Fig15: Comparison Analysis of FFT vs. Wavelet for HAAR; DB; Biorthogonal Process Using 256QAM

7 CONCLUSION:-

In this paper we analyzed the performance of wavelet based OFDM system and compared it with the performance of DFT based OFDM system. From the performance curve we have observed that the BER curves obtained from wavelet based OFDM are better than that of DFT based OFDM.

We used three modulation techniques for implementation that are QPSK, 16 QAM and 64 QAM, which are used in LTE. In wavelet based OFDM different types of filters can be used with the help of different wavelets available. We have used daubechies2 and haar and biorthogonal wavelets, both provide their best performances at different intervals of SNR.

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