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Performance Comparison of FFT and DWT based MIMO-OFDM Communication Systems

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Abstract - In this paper, the performance of Dicrete Wavelet Transform (DWT) based Multi-user MIMO-OFDM is compared with the performance of FFT based MIMO-OFDM system. Wavelet based OFDM has lot of advantages compared to the FFT based OFDM. There is no need for cyclic prefix, flexibility and optimal resolution. Wavelets existed suitably in almost all the arenas of wireless communication schemes with OFDM which is a durable applicant for next peers of wireless scheme, i.e., third generation of partnerships project (3GPP) networks. Simulation created examination will be jumble-sale to simulate the double multicarrier schemes, DWT with Haar constructed multicarrier in addition with the predictable OFDM, less than the consequence of taking multiple antennas scheme, by BPSK and QPSK as dual modulation schemes in an additive white Gaussian noise channel (AWGN). Established on the bit error rate presentation to the transmission ability, the DWT constructed multicarrier scheme was superior to the predictable OFDM scheme.

Keywords - MIMO-OFDM, FFT, DWT, AWGN, 3GPP, BPSK,QPSK, AWGN

I. INTRODUCTION

An Orthogonal Frequency Division Multiplexing (OFDM) scheme remains a multicarrier modulation as well as multiplexing scheme which employs a similar processing method letting the synchronized broadcast of data arranged several thoroughly spread out, orthogonal sub-carriers. The distortion is the greatest enemy of all types of communication systems which is caused by the multi path fading channel. Multi path fading occurs in both domain i-e time domain as well as frequency domain, greatly reduced in an Orthogonal Frequency Division Multiplexing (OFDM). An OFDM is very extraordinary speeds data rates, spilted into number of subcarriers. The OFDM has lot of advantages, spectral efficiency is very high, to reduce the impulse noise over the channel, robustness against co-channel interference and inter symbol interference. The loss of efficiency is caused by cyclic prefix or guard interval. The wavelet transforms are used to develop the effectiveness of OFDM scheme.

The FFT based conventional OFDM system are used to multiplexing the signals together and also decode the data symbol by the receiver respectively. The cyclic prefix is added before the transmitting signal, to evade the inter-symbol interference (ISI) in addition to inter-carrier interference (ICI). The cyclic prefix is nothing but periodic extension that is to increase the delay spread. But, the CP is reduced the spectral suppression of the channels. Ripple transforms are used to as the alternative platforms for replacing the FFT based OFDM system. Discrete wavelet transform is mainly used in the OFDM system because it has Low Pass Filter (LPF) plus High Pass Filter (HPF) functional as a Quadrature Mirror Filters technique satisfying perfect renovation as well as orthonormal bases properties. This is also called as sub-band coding.

In wireless communication systems proposal the wavelets require valuable applicability, by way of channel characterization, interference modification, modulation then multiplexing, numerous access communication, Ultra Wide-band (UWB) communication, cognitive radio in addition interacting [7]. The Discrete Wavelet Transform (DWT) is castoff in a multiplicity of signal processing solicitations,

such by means of video compression, Internet communications compression, plus object recognition also numerical study [8].

The resolution of this paper is to execute simulation results and compare on the wavelet based MIMO- OFDM with Fourier based MIMO-OFDM. To improve the channel capacity of wireless communication system by the execution of Multiple- Input and Multiple-Output of the OFDM scheme. In order to improve signal quality and also increase the throughput and the spectral utilization of the bandwidth. MIMO systems remain furnished with several numbers of antennas at both transmitters in addition receiver side to develop communication performance [8]. MIMO proposals a substantial progress in data throughput devoid of supplementary bandwidth requirement [8]. MIMO communication system is very attractive technique in wireless communication system. Space time block coding technique (STBC) is used to develop the diversity performance of the MIMO-OFDM system.

II. FFT BASED MIMO-OFDM

MIMO systems used many antennas at either the transmitter or receiver (array of antennas) in wireless communication systems. The MIMO has been developed for several years for wireless systems. Solitary of the earliest MIMO to wireless communications uses came in mid1980 by the breakthrough developments by Jack Winters and Jack Saltz of Bell Laboratories. Now MIMO technology has aroused interest because of its possible applications in digital television, wireless local area networks, metropolitan area networks and mobile communication. Comparing to the Single input-single-output (SISO) system MIMO provides enhanced system performance under the same transmission conditions. First, MIMO system greatly increases the channel capacity, which is in proportional to the total number of transmitter and receiver arrays. Second, MIMO system provides the advantage of spatial variety, each one transmitting signal is detected by the whole detector array, which not only improved system robustness and reliability, but also reduces the impact of ISI (inter symbol interference) and the channel fading since each signal determination is based on N detected results. In other words, spatial diversity overs N independent replicas of transmitted signal. Third, the Array gain is also increased, which means SNR gain achieved by focusing energy in desired direction is increased. On the other hand, MIMO also cost more energy including both the transmission energy and the circuit energy consumption.

Spectral efficiency of MIMO system remains increased for a given convey power. Spectral efficiency remains the entire quantity of data bits each second for each hertz communicated as of single array to the added. This one successfully precedes benefit of random fading as well as multipath delay spread [3]. Later it proceeds numerous transmitter also receiver antenna it feats spatial diversity. Accordingly the ability is improved by announcing supplementary spatial channel oppressed with space-time coding. Meanwhile the amount of antennas next to the transmitter as well as receiver are improved that one computational complexity likewise upsurges therefore the presentation is degraded through the estimation error. Estimation for MIMO system, by way of N_x transmitters then N_R receivers, here exist $N_x * N_R$ channels towards be estimated. Signals are transmitted concurrently as of totally transmitters, hence superposition of completely the conveyed signals remain received via the receivers. MIMO has two modes of operation, open loop then closed loop. Both the open loop and close loop knows the channel state information (CSI) at the receiver side. SpaceTime Block Coding (STBC) as well as Space-Frequency Block Coding are examples of open-loop Transmit Diversity.

MIMO-OFDM has lot of advantages, to improve the communication performance, to improve spectral efficiency, to reduced multi path fadding. It supported both diversity coding and spatial multiplexing. MIMO can be classified into three catergerios, precoding, spatial multiplexing and diversity coding. Precoding is used to increases the received signal gain and to reduced the multi-path fading effects. Spatial multiplexing is used to spilt high data rate symbol into many lower data streams. Each low data rate stream exists transmitted from altered antenna with similar frequency channel[10].

These signals are arrived at the receiver with spatial multiplexing. This is more power technique to increase the channel capacity. This can be used for simultaneous transmissions to the multiple receivers known as space division multiple access or otherwise called as multi-user MIMO. FFT based MIMO-OFDM as shown in the figure.

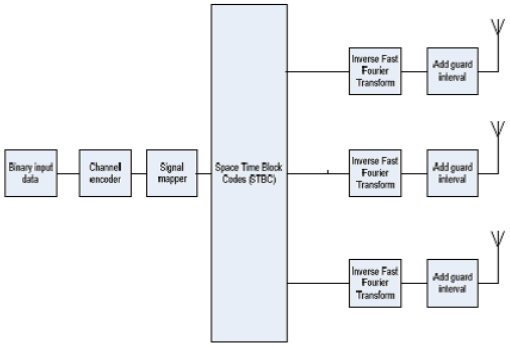

Fig 1. Block diagram representation of FFT based MIMO-OFDM Transmitter

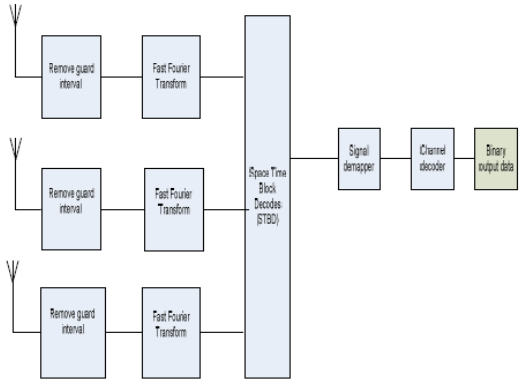

Fig 2. Block diagram representation of FFT based MIMO-OFDM Receiver

III. WAVELET BASED MIMO-OFDM

Wavelet Transform is an important mathematical function, because as a tool for multiresolution disintegration of continuous time signal by different frequencies also different times [5]. Now wavelet transform, upper frequencies are superior decided in time, as well as lesser frequencies are better decided in frequency. Happening this intellect, the signal remains reproduced through an orthogonal wavelet purpose, in addition the transform is calculated independently changed parts of the time domain signal [9]. The wavelet transform can be classified as two categories, continuous ripple transform and discrete ripple transform.

The Discrete Ripple Transform could be observed by way of sub-band coding. The signal is analysed and it accepted over a succession of filter banks [7]. The splitting the full-band source signalinto altered frequency bands as well as encrypt every band separately established on their spectrum vitalities is called sub-band coding method. The learning of sub-band coding fright starting the digital filter bank scheme, it is represented as a set of filters with has altered centre frequencies. Double channel filter bank is mostly used in addition the effective way to tool the discrete ripple transform (DRT) [5][8]. Naturally, the filter bank proposal has double steps which are used in signal transmission scheme. The first step is named as analysis stage which agrees toward the decomposition procedure in which the signal samples remain condensed by double (down sampling). Another step is called synthesis period which agrees to the exclamation procedure in which the signal samples are improved by two (up sampling).

The analysis period involves of sub-band filter surveyed by down sampler while the synthesis period involves of sub-band filter situated next up sampler. The sub-band filter period used through the channel filter exists perfect restoration Quadrature Mirror Filter (QMF) [8]. Subsequently there are low pass filter as well as high pass filters at each level, the analysis period takes double output coefficients also they are named asestimate coefficients which contain the small frequency information of the signal then detail coefficients which comprise the high frequency data of the signal. The analysis period of the multi-level double channels impeccable restoration filter bank scheme is charity for formative the DWT coefficients [5]. The procedure of restoration the basis signal as of the DWT coefficients is so-called the inverse discrete Ripple transform (IDRT). Aimed at each level of restoration filter bank the calculation then details coefficients are up sampled in addition to passed over low pass filter and high pass synthesis filter.

Discrete Wavelet Transform is planned as high presentation digital signal processing method for procedure in applying multicarrier modulation. The block diagram proposal of multicarrier transceiver arithmetical system constructed on DWT is shown in Fig. 2. The system project include of an inverse discrete wave-let transform (IDWT) as modulator at the transmitter as well as a discrete ripple transform (DWT) as demodulator at the side of receiver. The foremost plus the essential modification among the conventional OFDM as well as DWT multicarrier scheme is the removal of the cyclic prefix blocks in the transmitter otherwise in the receiver parts. The possessions of wavelets in addition to varieties it by way of a moral excellent for countless applications identical image synthesis, nuclear engineering, biomedical engineering, magnetic resonance imaging, music, fractals, turbulence, puremathematics, data compression, computer graphics also animation, human vision, radar, optics, astronomy, acoustics and seismology, and an deep description for additional applications remained offered in [1][2].

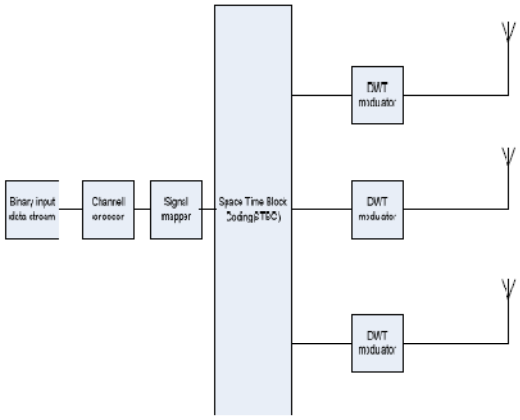

Fig 3. Block diagram representation of DWT based MIMO-OFDM Transmitter

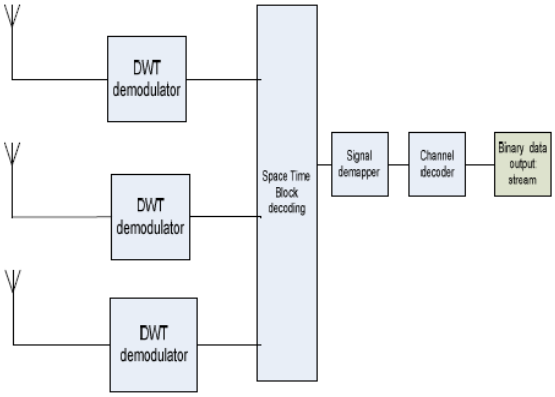

Fig 4. Block diagram representation of DWT based MIMO-OFDM Receiver

IV. SIMULATION RESULTS USING MATLAB

Figure 5 and 6 shown the graphical representation of FFT based MIMO-OFDM and DWT based MIMO-OFDM. The simulation results based on BER (Bit Error Rate) versus SNR (Signal to Noise Ratio). The simulation results is based on the comparsion between FFT based multi-carrier modulation and DWT based multi-carrier modulation using QPSK as well as BPSK in AWGN channel. The probability of bit error rate for DWT based MIMO-OFDM is fewer than the proability of bit error rate for FFT based MIMO-OFDM system. The wavelet transform has several types, Haar, Daubechies4, Biorthogonal and reverse Biorthogonal transforms. The Haar wavelet transform is superior than other types wavelet transform. Evaluation between DWT based multicarrier as well as conventional OFDM in relationships of capability (the transmitted symbol measured bits each single multicarrier symbol) then the bandwidth consumption efficiency (the proportion between the distance of subcarrier that transmit data above the overall multicarrier symbol interval). This one is perceptible that the realizable capacity after with DWT as multicarrier is higher than the conventional OFDM whether the guard intervals exist or not. Figures 7 and 8 shows the Bit error rate comparison for the theory and simulated verisons of FFT and DWT based MIMO-OFDM systems for BPSK Modulation Scheme.

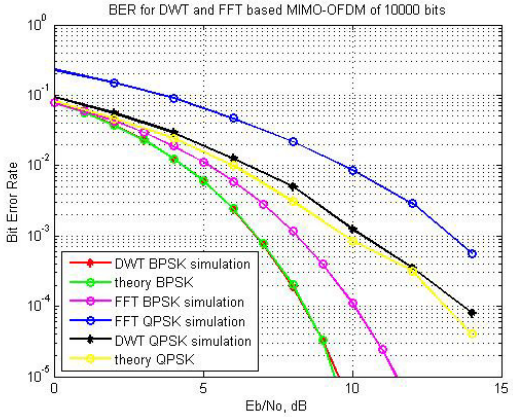

Fig 5. BER vs Eb/No for FFT and DWT based MIMO-OFDM for 10000 bits

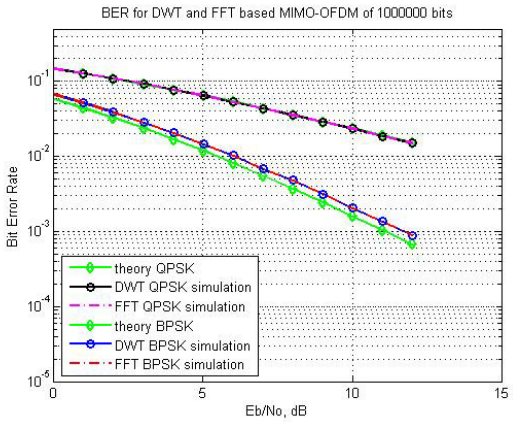

Fig 6. BER vs Eb/No for FFT and DWT based MIMO-OFDM for 1000000 bits

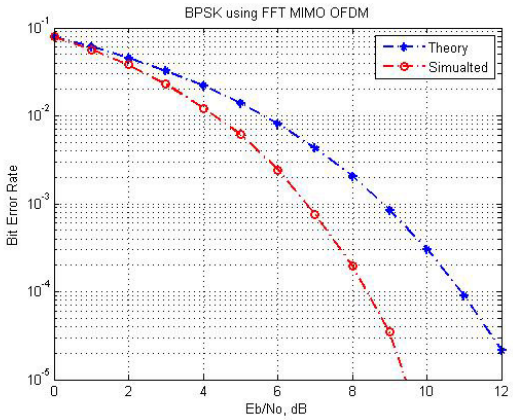

Fig 7. BER vs Eb/No for FFT based MIMO-OFDM for BPSK Modulation Scheme

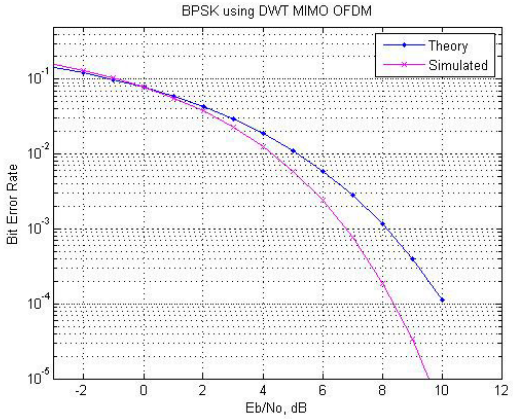

Fig 8. BER vs Eb/No for DWT based MIMO-OFDM for BPSK Modulation Scheme

V. CONCULSION

By comparing the simulation results DWT based MIMO-OFDM is best which is based upon the probability of bit error rate and transmission capacity. As there is no need for cyclic prefix that is periodic extension, in which last part of OFDM data is appended to the first part of OFDM data. The linear convolution is converted into circular convolution. To achieve higher data rate the DWT based MIMO-OFDM is better than the FFT based MIMO-OFDM. DWT based MIMO-OFDM is an important technique in modern wireless communication system for achieving high data rate with low bit error rate. Subsequently it was observed from the result of BER upsurges linearly through the total no of receive antennas due to upsurge in diversity demand also to the antenna array improvement in which extra receive antennas resources receive more power. Proceeding the other hand, later a certain side by side of upsurge of the transmit antennas, there is no greatly development. The BER presentation of communication schemes with binary phase shift keying (BPSK) is superior than by Quad-rature amplitude modulation (QPSK). Though, the data rate through QPSK is greater to BPSK. The related works are Wi-Fi, Wi-Max, 4G, HSPA (High Speed Packet Access).

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