Least Square Channel Estimation of Wavelet Based MIMO-OFDM System

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Abstract: **Today in wireless communication high speed data and good capacity to support a huge number of simultaneous users with more reliability is in high demand. The new horizons on these discussed topics have emerged as "hot cake" for researchers all over the world. . Many techniques, estimation methods, diversity schemes have been introduced to nullify the associated problem with speed and reliability in sending data. Generally the Discrete Fourier Transform (DFT) Tool and after that Fast Fourier Transform (FFT) has been adopted by the researcher's along with the MIMO-OFDM system for easier handling and computation of the system. However, the higher probability of occurring error has raises the concern in wireless communication. So, in this paper combined MIMO-OFDM system with different OFDM symbol duration has been considered with proposed Discrete Wavelet Transform Tool (DWT) in OFDM system for improved BER performance.**

Index Terms: Bit Error Rate (BER), Cyclic Prefix (CP), Inter Symbol Interference (ISI), Multiple-Input Multiple-Output (MIMO), Orthogonal Frequency Division Multiplexing (OFDM).

I-INTRODUCTION

Wireless communication services are penetrating into our society with an immense growth rate. According to the International Mobile Telecommunications-2000 (IMT-2000), the upcoming generation of wireless communications is consider to carry the features of, high security broadband transmission, global mobility, and a better quality of service (QoS) having low cost for both subscribers and operators. The above features are creating technical challenges on system design, power consumption and stimulating various research issues on complexity, capacity and performance. For immediate solutions of these problems, many diversity techniques, schemes and algorithms are introduced to enhance power efficiency, reliability and BER performance of the system.

The problem of proper channel utilization of wireless communication system has been resolved by the implementation of Multiple- Input and Multiple-Output (MIMO) scheme. It improves the signal quality and throughput performance of the system [1]. MIMO system has always been a well equipped system with several numbers of transmitting and receiving antennas in order to develop communication performance [5]. It is basically based on diversity techniques which help to increase spectral efficiency and diversity for accommodating more users and mitigating fading.

Multicarrier Modulation (MCM) is a progressively rising and efficient modulation scheme that divides the higher data rate into lower data rate. Also, it features to handle impulsive noise, channel fading and ISI.OFDM is a multicarrier scheme which is being commonly used nowadays. The scheme is widely adopted and rapidly used for transmission and reception process across the world [1]. The inverse Fast Fourier Transform (IFFT) and Fast Fourier Transform (FFT) is being used in OFDM to multiplex and de-multiplex the signals together in transmitter and receiver respectively [1]. Earlier, instead of FFT the Discrete Fourier Transform (DFT) tool was being used, but due to complexity in computation it is avoided nowadays. A Cyclic Prefix (CP) is added to data signal in a OFDM symbol before transmission. The aim of this CP is to mitigate ISI effect on transmitted signal. However, the CP has drawback of decreasing the spectral efficiency of the channel and more power consumption [2].

Wavelet transformation has recently risen as a strong contender for digital (wireless) communications [3]. In DFT/FFT based OFDM systems, signals overlap only in the frequency domain while DWT based OFDM signals overlaps both in the frequency as well as in time domains, so inclusion of CP is not required as like in the case of DFT/FFT based OFDM. So, by utilizing this transformation, the spectral efficiency of the channel get improved [4].

The paper proposed work, is having a 5×5 DWT based MIMO-OFDM system in the presence of AWGN channel, which has been estimated by Least Square channel estimation method, for detecting the performance of system with higher number of transmitter/receiver. This paper work includes BER performance comparison of different length OFDM symbol with different modulation schemes and order. In II part of this paper the literature Survey has been discussed, which illustrates existing FFT based OFDM system. In section III the proposed model DWT based OFDM system with MIMO has been considered. In section IV the LS channel estimation technique has been discussed and at last in section V have the results based on MATLAB simulation.

II- LITERATURE SURVEY

MIMO-OFDM has many advantages like enhancing the communication process, improving spectral efficiency, and reducing multi path fading effect. It supports spatial multiplexing as well as diversity coding. Spatial multiplexing has been used for splitting higher data rates symbol into multiple lower data symbols. Each low data rate symbol has been transmitted from different antenna with similar frequency channel [10]. For generating the OFDM symbol, firstly, consider the required spectrum and the modulation scheme which is going to be used for symbol mapping. The binary input data bits are encoded and then mapped by different modulation scheme that decides the amplitude and phase of the signal and converts it into waveform pattern. Further, the data is being processed through parallel to serial buffer stage that divides the symbol into multiple sub-streams. Each sub-stream is being modulated onto the subcarrier by IFFT tool. Then the signal is being transmitted through AWGN/Rayleigh noisy channel, where it faces the problem of ISI. To make system overcome by this problem, researchers included a guard interval called as cyclic prefix. Further at receiver end the signal is being processed with FFT tool in order to get originally transmitted signal back.

Equation for IFFT is

$$x(m) = \frac{1}{N}\sum_{l=0}^{N-1} X(k)e^{i*2*pi*l*\,m/N} \quad (1)$$

Equation of FFT is

$$X(k) = \sum_{k=0}^{N-1} x(m)e^{-i*2*pi*l*m/N} \quad (2)$$

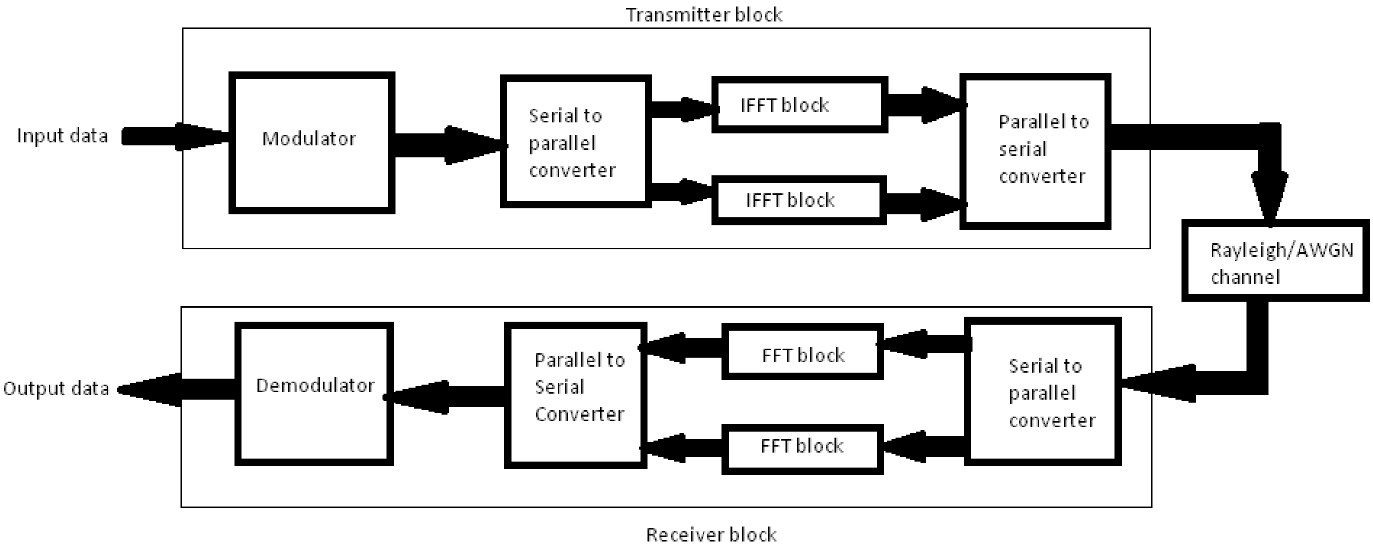

Fig.1 FFT based OFDM transceiver system

III-DWT BASED MIMO-OFDM SYSTEM

In the proposed system the basic principle of DWT based MIMO-OFDM system has been considered, in which the IDWT and DWT tool is used for demodulation and modulation process. Wavelet transform is being an additional approach to observe the signal in both time and frequency domain [6]. It satisfies orthogonality rule and used for carrying data in OFDM system. The wavelet transform is more preferable because of its better frequency and time localization. It is a mathematical tool which basically breaks the signal into a set of multiple mutually orthogonal wavelet basis functions and used to give time-frequency representation of any non-stationary signal [7]. It analyzes the signals at different scales by passing the signal to the filters of having different cutoff frequencies [9]. The signal is broken into various sub-bands, one is forwarded through low pass filter and other one is forwarded through high pass filter repeatedly [8]. The low passed one produces approximation coefficients, leaving out the detailed one and the high passed one signal are called as detail coefficient leaving out approximate part of the signal by taking the detailed one only. The wavelet carriers are the IDWT and DWT coefficients, which are being obtained from the mother wavelet $\Psi(t)$

$$\Psi_{k,m}(t)=2^{-k/2}\Psi(2^{kl}t-m) \quad (3)$$

here, k is the scaling parameter and m is the position on time axis. IDWT based OFDM symbol is being considered as weighted sum of scaled carriers and wavelets. Equation for IDWT is given by [9]

$$(x(n)) = \sum_{l=-\infty}^{\infty} \sum_{k=-\infty}^{\infty} X(l,k)2^{l/2}\Psi(2^{l}n-k) \quad (4)$$

Equation for DWT of x(n) is given by [11]

$$X(l,k)= \sum_{n} x(n)2^{l/2}\,\Psi(2^{l}n-k) \quad (5)$$

Fig.2 shows the transceiver of DWT based MIMO-OFDM system in which the data is carried through noisy channel by the help of multiple carriers. It is just a replacement of IFFT/FFT blocks with IDWT/DWT in fig.1having no CP addition and removal process.

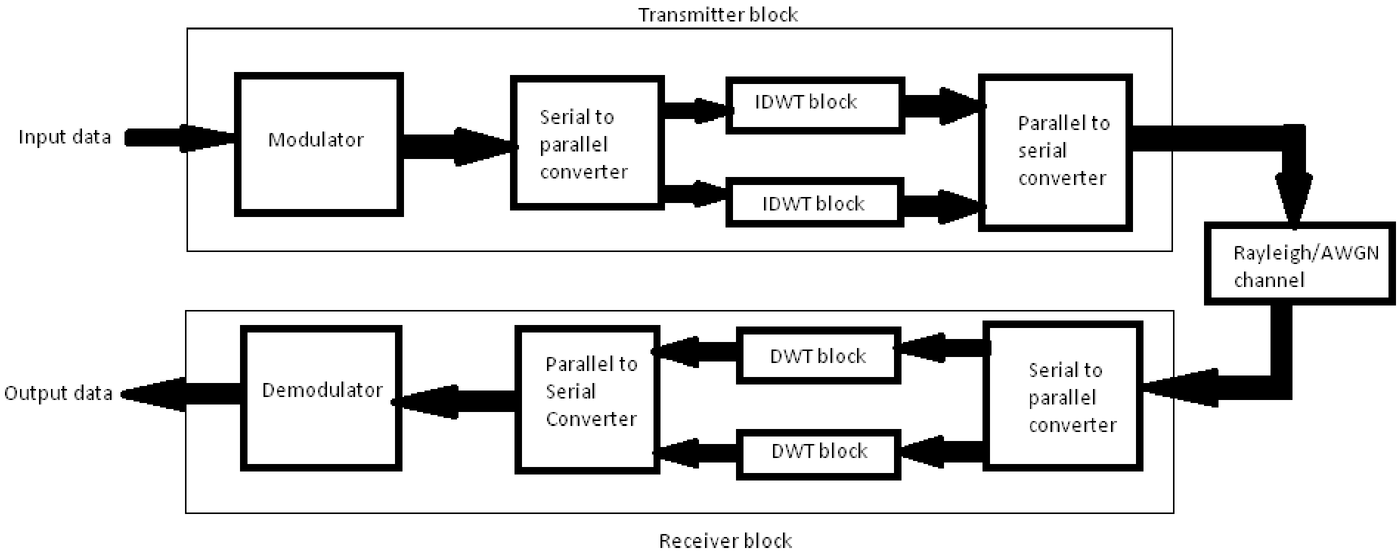

Fig.2 DWT based OFDM transceiver system

IV-CHANNEL ESTIMATION

Channel estimation is a technique for knowing the channel behavior and impulse response, in order to avoid the channel impairment. It is based on known data, if the transmitted and received data both are known then such method is called as training based or pilot based estimation method and if only received data is known then it is known as blind channel estimation approach. In this paper, least square method has been considered as it involves inverse of a matrix which is less complex to evaluate than the other pilot based estimation method. Blind channel estimation is done by estimating the statistical information of channel and the specific properties of signal. The least square estimation method is a quite simple parallel interference cancellation technique, which is being widely used for improving data symbol detection. It also hold good for handling large count of transmitter and receiver as it has very less computational complexity. The channel estimation is given by

$$\hat{H} = X^{-1}Y \qquad (6)$$

Where X is the pilot diagonal matrix, Y is a received matrix and H is estimated channel matrix here

$$X^{-1} = \begin{bmatrix} \frac{1}{X(0)} & 0 & 0 & \cdots & 0 \\ 0 & 0 & \vdots & \ddots & 0 \\ 0 & 0 & & .. & \frac{1}{X(N)} \end{bmatrix} \qquad (7)$$

$$Y = \begin{bmatrix} Y(0) \\ \vdots \\ Y(N) \end{bmatrix} \qquad (8)$$

V- SIMULATION RESULTS

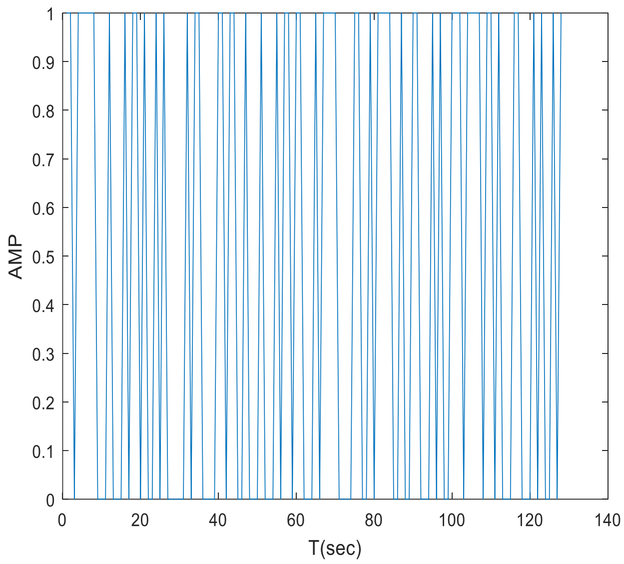

Fig.3 Input data

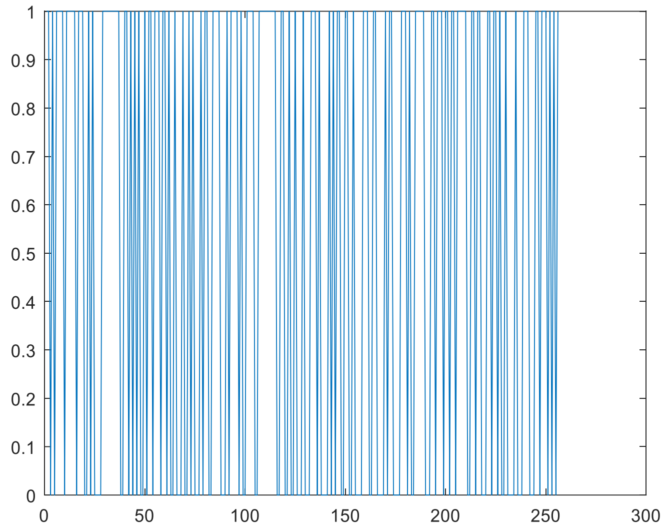

Fig.4 Encoded data bits

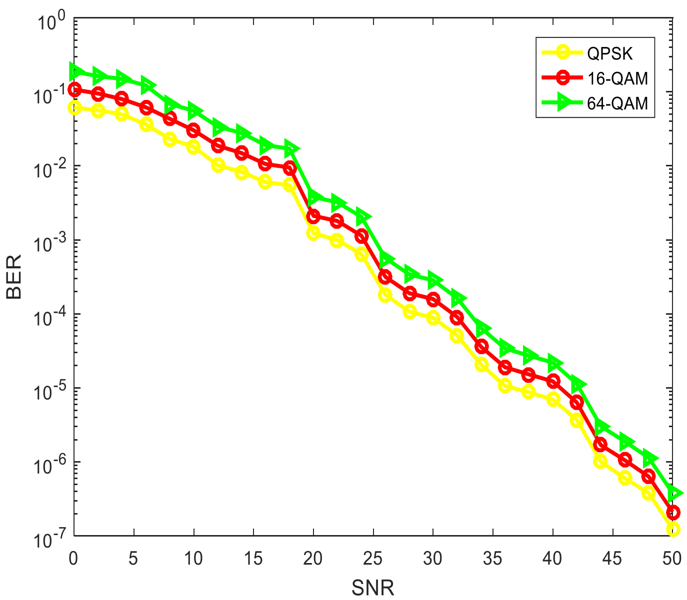

Fig.5 BER performance of DWT-MIMO-OFDM system

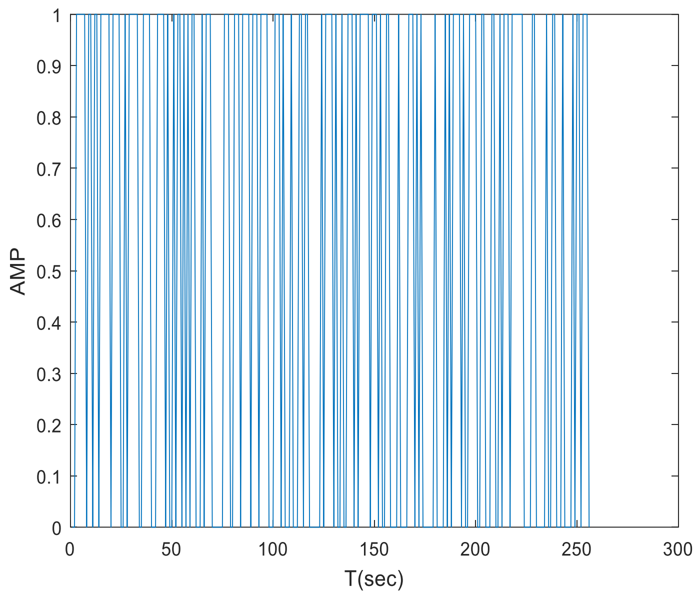

Fig.6 Input data bits

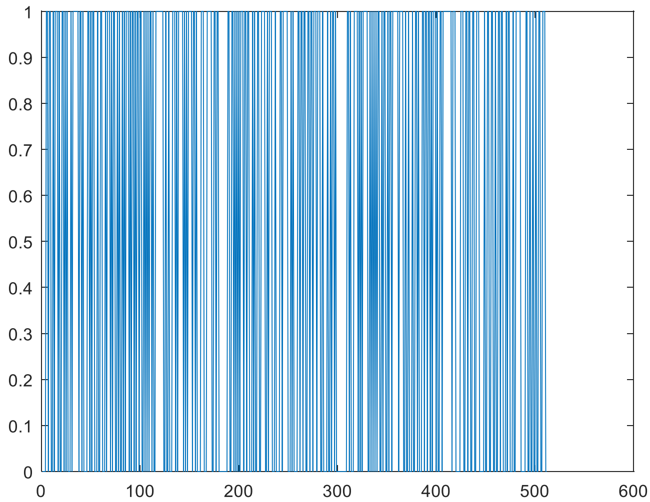

Fig.7 encoded data signal

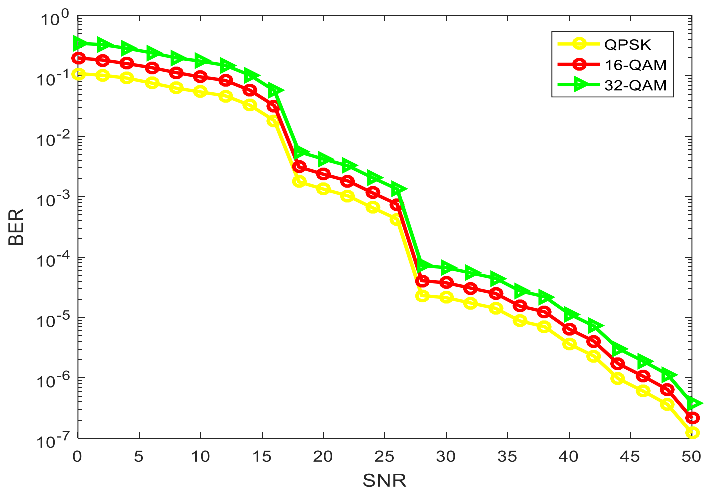

Fig.8 BER performance of DWT-MIMO-OFDM

Table-I: MIMO-OFDM system specification

Parameter	Specification DWT-MIMO-OFDM system
Channel Model	AWGN channel
Modulation	QPSK,16-QAM,64-QAM
Diversity Scheme	5×5
Channel estimation	Least square
Number of subcarriers	1024
OFDM symbol length	52 bits and 116 bits
Input message bits	128, 256
Code Rate	½
Number of iterations	100

Fig.3 shows the input data length of 128 bits get encoded by the rate of ½ gives 256 encoded bits shown in fig.4. Fig. 5 represents the BER performance of system with different modulation schemes and order. QPSK has the lowest BER among the 16-QAM and 64-QAM, as also follows the theory assumption of sending lesser number of bits at a time results in less probability of error. So, 64-QAM has the highest probability for occurring error while transmission. Fig.6 shows the simulated result of input signal having 256 bits which get Convolutional encoded into 512 bits shown in fig.7.

Fig.8 shows the same result as fig.5 has, as QPSK has the minimum BER, and the system with greater symbol width has higher BER which resembles with the theory prediction also. As, the SNR value of system increases that is the content of noise power in signal decreases the possibility of occurring error also decreases, following the inverse pattern. At, 0 db SNR value the system has maximum BER while at 50 db SNR value system shows the better performance with very less BER.

VI-CONCLUSION

As, in fig 3 and in fig.5, the number of bits transmitted is being increased, because of which the encoded number of bits according to ½ code rate also get increased, showing that the increase in the number of bits in the available bandwidth leads to greater chances of occurring error. The channel coding in a system is done to make system safe from interference and noise, but it also introduces redundancy by increasing number of bits for a transmitted signal, which are used at receiver end causing more tendency for having error. Also, in fig.5 and fig.8 shows increase in number of bits transmitted at a time as due increase in order and change in modulation scheme, leads to poor performance of system. Lower order modulation scheme give the better results than the higher one.

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