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Channel Estimation of Wavelet-Based MIMO-OFDM Systems Using Least Square Estimator and KALMAN Algorithm

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Abstract: In Wireless Systems, Multiple Input Multiple Output (MIMO) and Orthogonal Frequency Division Multiplexing (OFDM) are two combined technologies which provide high data transmission rate with multicarrier modulation. MIMO technology uses spatial diversity technique by using multiple antennas at transmitter and receiver side. Multiple signals are transmitted from different antennas using the same frequency and separated space. In this paper, DWT (Discrete Wavelet Transform) is presented as a replacement of FFT (Fast Fourier transform) since there is no need of CP (Cyclic Prefix) due to the overlapping properties of DWT. By this simple replacement, improvement of performance has been detected which leads to new system scenario of DWT based MIMO-OFDM systems. Various channel estimation techniques are employed in order to judge the physical effects of the medium present. In this paper, we analyze and implement various estimation techniques for MIMO-OFDM Systems such as Least Squares (LS) and KALMAN by using different modulations like QAM (Quadrature Amplitude Modulation), PSK (Phase Shift Keying), BPSK (Binary Phase Shift Keying). These techniques are therefore compared to effectively estimate the channel in MIMO-OFDM System. The results demonstrate that SNR required to support different values of Bit Error Rate (BER) varies depending on the different low correlation between the transmitting and the receiving antennas.

Keywords: Channel Estimation, Least Square (LS), KALMAN, DWT, QAM, PSK, BPSK.

I. INTRODUCTION

To accomplish good performance in high data rate transmission discrete wavelet are utilized. Channel estimation is done by inserting pilot symbols [1,2]. There are two methodologies for inserting pilots like block type pilot, comb type pilot. Comb type pilot prompts to better SNR (Signal to Noise Ratio). This paper contrasts the performance of pilot based channel estimation using different modulation schemes. Comb type pilot has a higher degree of transmission rate as contrasted to pilot arrangement. Channel estimation is used for noise detection and decoding of the wireless signal to decrease noise and the interference [2]. The wireless channel experience the ill effect of multipath propagation and signal fading. And the channel transfer function is time variant. Therefore, channel estimation is required to track the channel to assess how it distorts the transmitted signal. Wavelet-based OFDM satisfy the condition for orthogonality [3]. The wavelet transform is a device for examination of the signal in time and in the frequency domain. In this investigation, the signal is decomposed into frequency components and different modulation schemes are used like QAM, PSK, BPSK. Bit error rate is calculated. Fourier transform has the drawback of dealing with just frequency component in the signal whereas wavelets are functions that are concentrated in time as well as in frequency domain [4].

II. APPROACH

For the implementation, we have used MATLAB. MATLAB (Matrix Laboratory) is a tool for numerical computation and visualization [5]. MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, the creation of user interfaces, and interfacing with programs written in other languages, including C, C++, C#, Java, Fortran, and Python.

III. IMPLEMENTATION OF MIMO-OFDM SYSTEM

DWT based MIMO OFDM system is implemented using following steps Fig (1): Transmission, Channel, Reception. Transmission is further divided into following steps: Modulation, Serial to parallel conversion, Inverse Discrete Wavelet Transform (IDWT), Parallel to serial conversion. After that data is passed through UnderWater Acoustic Channel (UWAC) in the presence of additive white Gaussian noise (AWGN). The receiver includes following steps: Serial to parallel conversion, Discrete wavelet transform

(DWT), Parallel to serial conversion, Demodulation. At the receiver side, bit error rate is calculated after DWT. The input data bits are grouped and mapped into multi-amplitude and the mapped data symbols ψ(n) are transformed and combined to form a signal X(n) is expressed as:

$$X(n) = IDWT\{\psi(n)\} \quad (1)$$

Where, $\psi(n)=e^{j2\pi n/Tu\ (t-Ts)}$ (2)

$$z(t) = X(n)\ \psi(n),\ t(n) * g(n) \quad (3)$$

Where,

*= convolution operator

g(n) =Impulse response

Ts = Total time

ψ(n)= Subcarrier pulse (mother wavelet)

t(n) =Is the time

IV. UNDERWATER ACOUSTIC CHANNEL WITH NOISE

Signal s(t) is transmitted through the multipath channel and frequency selective fading channel with additive white Gaussian noise (AWGN) is expressed as:

$$s(n) = \sum_{p=0}^{N_p-1} h_p s(t-T_p) + W(n) \quad (4)$$

Where,

N_p=number of the propagation path

T_p= propagation time

h_p= path gain

w(n) = additive white Gaussian noise

On the other hand, at the receiver side reverse process is simulated using DWT. The signal will be processed to the demodulator for data recovery. After serial to parallel conversion DWT (Discrete Wavelet Transform) is done and is expressed as:

$$Y(k) = DWT\ X(n) = (Y(n), \psi(n)) \quad (5)$$

$$= 2^{-n/2} \sum_{n=-\infty}^{\infty} X(n)\ \psi(2^{-n} n-k)$$

Where,

Ψ is the mother wavelet function used in DWT based MIMO-OFDM system. 2^{-n} and n-k are shifting and scaling parameters. The transmitted data signal Y(k) is written in the frequency domain as:

$$X(k) = y(k) / s(k) \quad (6)$$

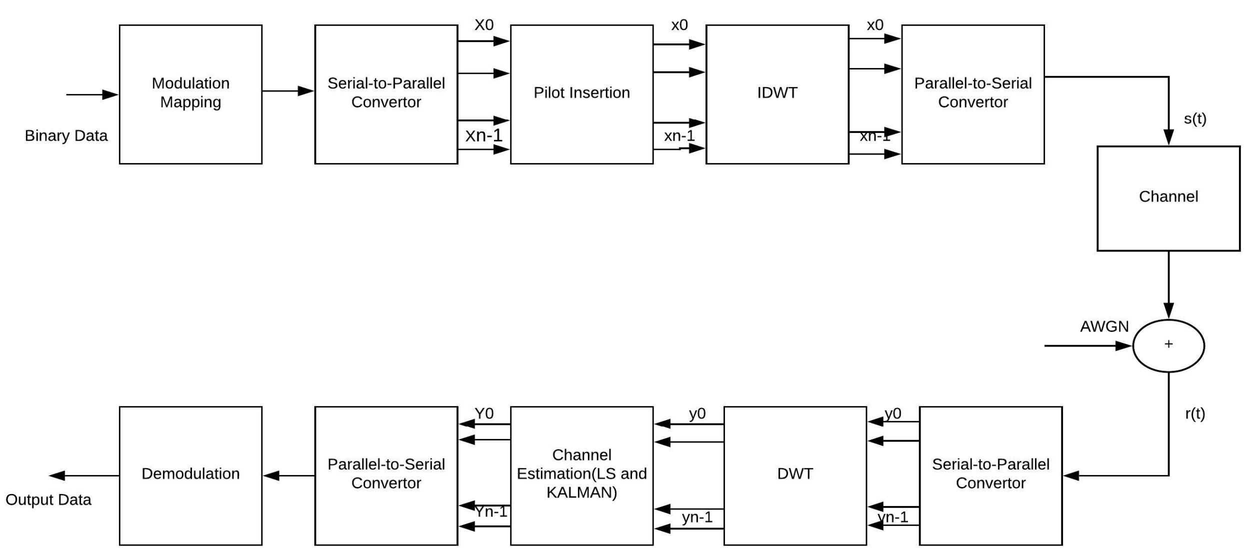

Fig. 1: DWT based MIMO-OFDM

V. LEAST SQUARE ESTIMATOR

Least square estimator is characterized as the proportion between the input data sequence and the output. the least square has low complexity [6]. In the least square error estimation (LSE), technique ratio of received data to the transmitted data is taken to calculate channel impulse response. Transmitted data is represented as:

Where,

Ψ is the mother wavelet function used in DWT based MIMO-OFDM system. 2^{-n} and n-k are shifting and scaling parameters. The transmitted data signal Y(k) is written in the frequency domain as:

$$X(k) = y(k) / s(k) \quad (6)$$

where 'T(n-1)' represents Tx = [T(0) (1) T(2)…………….T(n-1)]

'n^{th}' bit from total 'k' transmitted bits. The received signal is represented as:

Rx = [R(0) R(1) R(2)…………….R(n-1)]

where 'R(n-1)' represents 'n^{th}' bit from total 'K' received bits. To calculate the impulse response of channel ratio of received to transmitted signal is taken as:

$$H(K)= Rx /Tx \quad (7)$$

Error 'e' is calculated as: e=desired response-actual response

LS estimator minimizes the error 'e'. Due to low complexity least square implemented easily. But least square suffers from high mean square error.

VI. KALMAN FILTER

KALMAN Filtering is an effective method to filter impurities in linear systems. The KALMAN filter is an iterative mathematical process that uses consecutive data inputs and a set of equations to quickly estimate the position, true values, the velocity of the object being measured when the measured values contain unpredicted or random error, uncertainty or variation. KALMAN filter works repeatedly on streams of noisy input data to produce statistically ideal outcomes [7]. Originally, the filter was used to solve the problems of separating unwanted components of gas, liquid, and solid mixtures. KALMAN filter is powerful in several viewpoints as it supports estimation of past, present, and even future states.

The KALMAN filter is an optimal estimator for indirect, inaccurate and uncertain observations and evaluates the state estimate that minimizes the mean square error. Simply, it 's a physical device for removing unwanted fractions of mixtures. This filter consists of numerical equations that estimate the state of a process that minimizes the mean of the squared error.

The discrete KALMAN filter estimates the states of a linear system described by the difference equation:

$$x(k) = Ax(k-1) + Bu(k-1) + w(k-1)$$

by treating it as an optimization problem, solved by minimizing the estimator error covariance P. Available measurements of states are given by

$$z(k) = Hx(k) + v(k)$$

where the process disturbance w∼N(0,Q) is normally distributed white noise, with zero mean and variance Q, and the measurement disturbance v∼N(0,R) is normally distributed white noise with zero mean and variance R.

The KALMAN filter makes predictions of the states based on previous estimated states and control signals. Then it calculates an observer gain K based on properties of the system and process disturbances. The estimates are calculated by weighing predicted states and measured states against each other, such that it minimizes P.

Since only the estimates of the states can be determined, x will henceforth be approximated with the estimated states ˆx.The procedure of the KALMAN filter for one sample :

A. *Predict States*

$$xˆp(k) = Axˆ(k-1) + Bu(k-1)$$

B. *Predict Error Covariance*

$$Pp(k) = AP(k-1)A> + Q$$

Compute the KALMAN gain

$$K(k) = Pp(k)H>(HPp(k)H> + R)-1$$

Estimate the states by correcting the predictions with measurements:

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$\hat{x}(k) = \hat{x}_p(k) + K(k)(z(k) - H\hat{x}_p(k))$

Update the error covariance:

$P(k) = (I - K(k)H)P_p(k)$

VII. WAVELET TRANSFORM

Wavelet Transform can represent the signal in a time domain. This can separate the input signal into a set of values that can classify the signal frequency component at given timeframe. The wavelet transform is also known as 'mother wavelet' [8]. The wavelet transform is ordered into two classifications: - Continuous Wavelet Transform (CWT) and Discrete Wavelet Transform (DWT).

A. CWT (Continuous Wavelet Transform):

CWT of a time domain signal f (t) is calculated using this equation:

$$F(x,y) = \int_{-\infty}^{+\infty} f(t)\varphi_{x,y}(t)dt$$

Where x and y are scale and shift parameters, respectively $(\varphi(t))$ is a mother wavelet function. Mother wavelet function must need to fulfill following equation:

$$\int_{-\infty}^{\infty} \varphi(t)dt = 0$$

The parameter 'y' moves the wavelet so that neighborhood data around time t=y is held in the transformed function.

B. DWT based MIMO OFDM

The execution of the DWT based MIMO-OFDM is gotten by just replacement of FFT/IFFT block with DWT/IDWT. In which DWT based MIMO-OFDM after demodulation utilizing constellation mapped symbol will be carried over by the wavelet carrier where wavelet carrier is IDWT coefficients [8,9].In DWT based MIMO-OFDM system there is no need to add cyclic prefix and it provides the analysis of the signal in both time and in the frequency domain. The Bit Error Rate (BER) of this method is better than the FFT (Fast Fourier Transform) based MIMO-OFDM system. A discrete wavelet transform (DWT) is a wavelet transform for which the wavelets are discretely tested [10]. There are different types of wavelets like HAAR wavelets, Daubechies wavelets and The dual-tree complex wavelet transform (DCWT) [11,12]. HAAR wavelet HAAR wavelet is a grouping of rescaled square-shaped functions. These functions together form a wavelets family. Wavelet analysis is like Fourier analysis in that it allows a target function over an interval to be represented in terms of an orthonormal basis.

VIII. SIMULATION AND RESULT

The system has been simulated utilizing MATLAB. During simulation 64 subcarriers are used and different modulations are being used. In the wavelet-based system at the transmitter, IDWT is performed. The value of SNR (Signal To Noise Ratio) is taken from (0 dB to 40 Db).

For the transmission of data from a transmitter to the receiver Underwater acoustic channel along with AWGN channel is used. In this paper, different channel estimation techniques are utilized like LS and KALMAN. In this paper Rayleigh fading and AWGN (additive white Gaussian noise) are utilized. BER performance of LS and KALMAN estimation technique is performed over AWGN channel. The performance of least square base channel estimation is contrasted with a minimum mean square error in terms of Bit Error Rate (BER).

OFDM schema is a multicarrier transmission approach dependably faces multipath propagation and multipath fading. DWT expands the efficiency of transmission. The wavelet transform used to decompose a continuous time signal, when the signal is passed through wavelet it produces the signal with different scale and a different time. The comparison of the BER performance of LS and KALMAN using different modulations is shown in the figures.

Table 1. Different channel parameters for simulation.

Simulation Parameters	Value (DWT based MIMO-OFDM)
Modulation	QAM ,PSK,QPSK
Subcarriers	64, 128, 256
No. of symbols	100
Constellation	64
Type of channel	AWGN/Rayleigh flat fading
SNR range	[0:2:40]

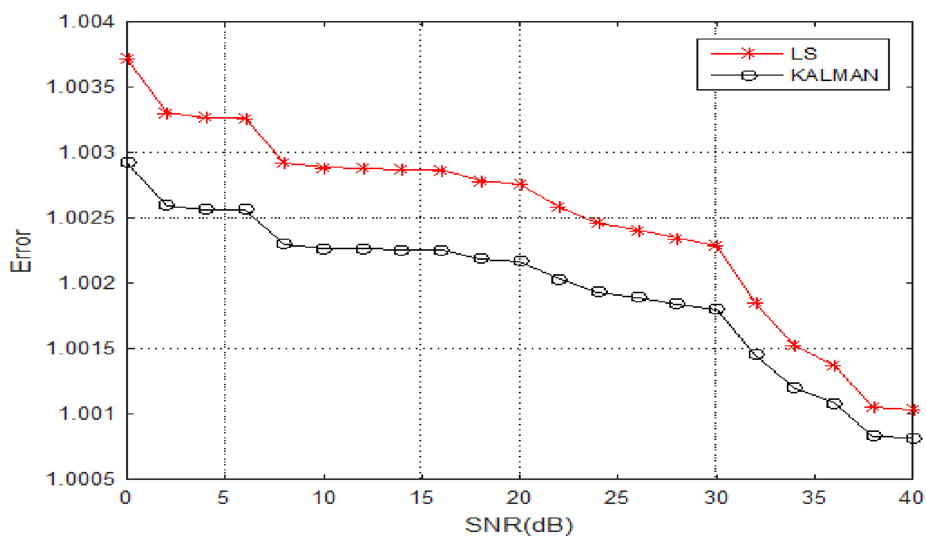

Fig. 2. BER of LS and KALMAN DWT based MIMO-OFDM using QAM modulation

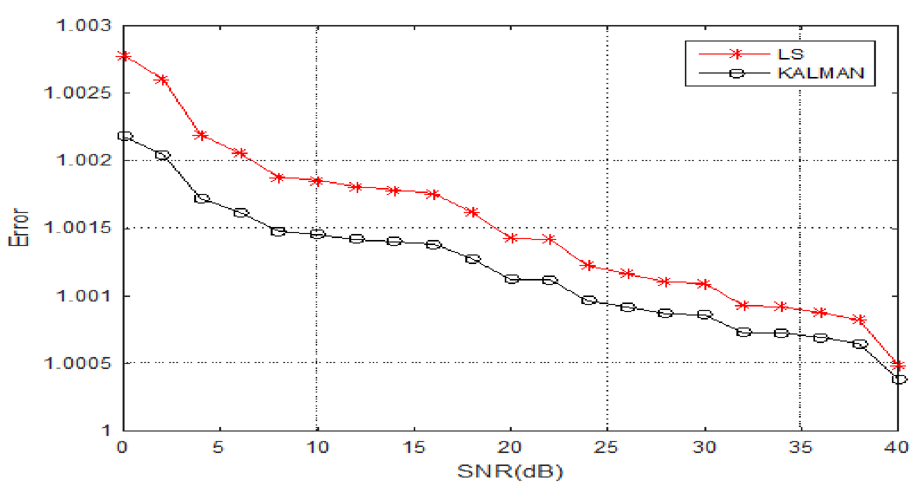

Fig. 3. BER of LS and KALMAN DWT based MIMO-OFDM using PSK modulation

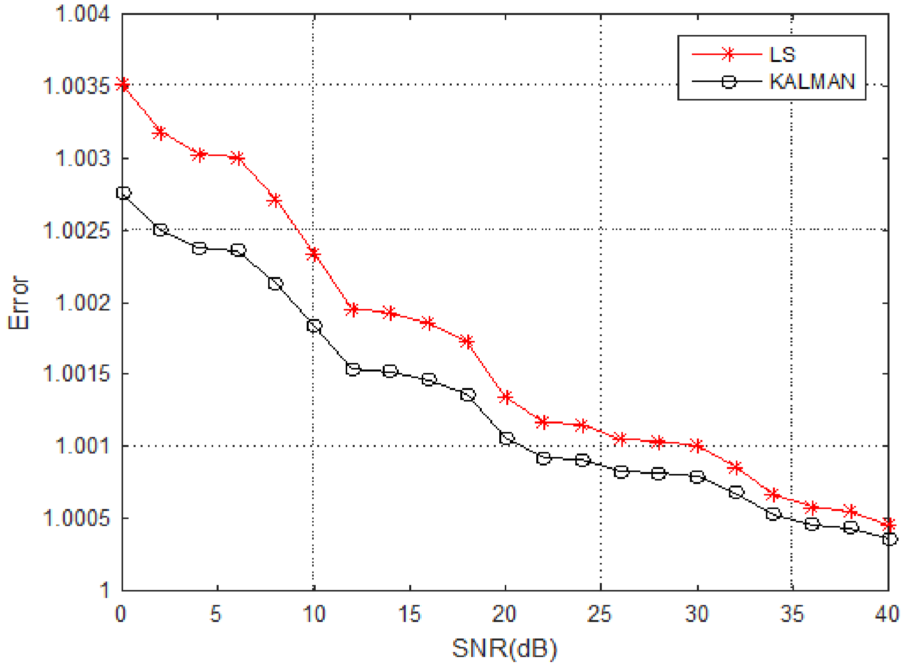

Fig. 4. BER of LS and KALMAN DWT based MIMO-OFDM using BPSK modulation

IX. CONCLUSIONS

In this paper, BER (bit error rate) is computed. The transmitted signal goes through numerous reflection, refraction, multipath fading, and propagation. At the receiver, channel effects must be canceled to recover the original signal. The BER is figured over a range of SNR values from 0 dB to 40 dB. In this paper, LS and KALMAN are compared using channel estimation techniques. Discrete wavelet is utilized as a part of this paper by just replacement of the FFT with DWT. DWT builds the efficiency and the value of SNR increases the difference between the BER by LS and KALMAN using different modulations like QAM, PSK, BPSK. As the use of wavelets, orthogonality between subcarriers remain better and this results in better performance of the system. In this, we observed that the accuracy of KALMAN is better than that of LS Estimator. And also the BER is minimum in KALMAN as compared to the LS Estimator. As a result, we found that KALMAN performs better than LS (Least Square) Estimator.

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REFERENCES

[1] A. Vamsidhar, P. Rajesh Kumar, and K. Raja Rajeshwar," A new approach to the investigation of discrete wavelet-based multiuser MIMO-OFDM for BPSK modulation scheme", Springer Nature Singapore Pte Ltd. 2018.
[2] Ali Asadi and Behzad Mozaffari Tazehkand, "A New Method to Channel Estimation in OFDM Systems Based on Wavelet Transform" International Journal of Digital Information and Wireless Communications (IJDIWC) 3(1): 1-9 The Society of Digital Information and Wireless Communications, 2013 (ISSN: 2225-658X)
[3] L. Madan Kumar, N Homayeun," A review of wavelets for digital wireless communication", wireless personal communication, Kluwer Academic Publishers, Vol,37 no.3-4, pp.387-420, May 2006.
[4] Asma Bouchlel, Anis Sakle, Nejib Mansouri, "Performance comparison of DWT based MIMO-OFDM and FFT based MIMO-OFDM, 2005.
[5] M. Weeks, Digital Signal Processing using MATLAB and the wavelets Georgia state university, 2007.
[6] Mohammed Ali Mohammed MOQBEL1 , Wangdong2 , Al-marhabi Zaid Ali3 " MIMO Channel Estimation Using the LS and MMSE Algorithm" Hunan University, Changsha, Hunan, China 3Hajjah University, Hajjah, Yemen IOSR Journal of Electronics and Communication Engineering (IOSR-JECE) e-ISSN: 2278-2834,p- ISSN: 2278-8735.Volume 12, Issue 1, Ver. II (Jan.-Feb. 2017), PP 13-22

[7] Ashish Kr. Gupta, Mukesh Pathela, Arun Kumar "Kalman Filtering based Channel Estimation for MIMO-OFDM" Dehradun Institute of Technology, Dehradun International Journal of Computer Applications (0975 – 8887) Volume 53– No.15, September 2012.
[8] M. K. Lakshmanan, and H. Nikookar, A Review of Wavelets for Digital Wireless Communication, Wireless Personal Communications, Vol.37, (2006), pp. 387-420.
[9] A. Vamsidhar, P. Rajesh Kumar, and K. Raja Rajeshwar," A new approach to the investigation of discrete wavelet-based multiuser MIMO-OFDM for BPSK modulation scheme", Springer Nature Singapore Pte Ltd. 2018.
[10] V. Kumbasar, et al., "Optimization of wavelet-based OFDM for multipath powerline channel by genetic algorithm," Wireless Communications and Mobile Computing, Vol. 9, No. 9, pp. 1243-1250, 2009.
[11] Anuradha, N. Kumar, " BER analysis of conventional and wavelet-based OFDM in LTE using different modulation techniques" in Proceedings of Engineering and Computational Sciences (RAECS), UIET Panjab University Chandigarh, India, IEEE, pp.1-4, March 2014.
[12] Abdullah., Hussain.: Studies on DWT-OFDM and FFT-OFDM systems, ICCCP, 2009.