AN EFFICIENT ITERATIVE LMMSE CHANNEL ESTIMATION IN OFDM COMMUNICATION SYSYTEM

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ABSTRACT: Orthogonal Frequency Division Multiplexing (OFDM) has recently been applied in wireless communication systems due to its high data rate transmission capability with high bandwidth efficiency and its robustness to multi-path delay. The main objective is to transmit the data with low bit error rate and error free transmission in the noisy environment. This is called as the Enhanced iterative LMMSE channel estimation algorithm (EI-LMMSE-CE).This algorithms have been proposed to achieve the future requirements such as very high convergence rate, less BER, robustness to noise. Also, it is shown that the resulting steady state mean square error (MSE) of the proposed algorithms are quite insensitive to changes in input signal-to-noise ratio (SNR). The performance of proposed algorithms is analyzed in terms of BER, SNR, and MSE.

KEYWORDS: Channel estimation, MSE, LLMSE, BER, SNR, MSE, and OFDM.

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1. INTRODUCTION

Orthogonal frequency division multiplexing (OFDM) is an efficient multicarrier modulation scheme which is resilient to the effect of multipath fading channels. Although all the OFDM subcarriers are modulated by waveforms that are limited in the time-domain, in practice, there is unavoidable power leakage in the frequency-domain and because of this; the guard band has to be placed so as to minimize adjacent channel interference to other coexisting wireless systems. Furthermore, OFDM's robustness against multipath propagation relies on the insertion of cyclic prefix (CP) which is a loss of spectrum efficiency [1].

In last decades, Orthogonal Frequency Division Multiplexing (OFDM) based communication a system has been identified as one of key transmission techniques for next generation wireless communication systems. The main attractions of OFDM are handling the multi-path interference, and mitigate inter-symbol interference (ISI) causing bit error rates in frequency selective fading environments. Wireless mobile communication systems of the 21st century have to confirm a wide range of multimedia services such as speech, image, and data transmission with different and variable bit rates up to 2 mbps. It is all recognized that there is a great impact of channel coding on the performances of OFDM based wireless communication system to provide high data rates over severe multipath channels [2].

Channel equalization is the process in which the transmitting signal affected by the unwanted signals during transmission process is trying to become noise free. The ISI (Inter Symbol Interference) imposes the main obstacles for achieving increased digital transmission rates with the required accuracy. Traditionally, inter symbol interference problem is resolved by channel equalization. A channel equalizer is an important component of a communication system. The equalizer depends upon the channel characteristics. The adaptive equalizer and the decision device at the receiver compensate the ISI created by the channel. Thus it may be necessary for the channel equalizer to track the time varying channel in order to provide reasonable performance. The main key goal of this adaptive filter based equalizer is to minimize the mean square error of equalized signals before reaching to the receiver [3].

We focus on Channel Estimation (CE) and Channel Length Estimation (CLE) for OFDM systems. CE plays a fundamental role in modern communication systems, especially for wireless devices. For a coherent communication, the channel must be estimated at the transmitter and/or receiver side. Knowledge of the Channel State Information (CSI) at the transmitter side is usually the most favorable condition, since the transmitter can apply smart techniques in advance, to adapt the communication to the environment conditions [6].

Channel estimation with equalization in OFDM systems is investigated. The main objective of this thesis is to investigate the performance of channel estimation in OFDM systems. The new algorithms have been proposed for channel estimation in this paper.

2. LITERATURE REVIEW

SU HU et.al: This paper is focused on training sequence design for efficient channel estimation in multiple input multiple-output filter bank multicarrier (MIMO-FBMC) communications using offset quadrature amplitude modulation (OQAM). MIMO-FBMC is a promising technique to achieve high spectrum efficiency as well as strong robustness against dispersive channels due to its feature of time-frequency localization. In this paper, authors proposes a new class of training sequences, which are formed by concatenation of two identical zero-correlation zone sequences whose auto-correlation and cross correlation are zero within a time-shift window around the in-phase position [1].

Petros S. Bithas et.al: Authors proposed a new threshold-based channel selection strategy, which decreases the system complexity, without considerably affecting the system performance. Assuming independent but non identically distributed channel conditions, a generic analytical framework is first presented, based on the Markov chain theory. Then, the proposed selection scheme is applied to three specific communication scenarios, namely multichannel reception; transmit antenna selection with diversity reception, and cooperative relay selection. In all three cases, closed-form results are obtained and used to analyze the performance of the systems under consideration. It is shown that based on the proposed scheme, computational complexity is reduced and thus important energy savings can be achieved, without a significant loss in performance [4].

Sunho Park et.al: Authors proposed a new decision-directed channel estimation technique dealing with pilot shortage in the MIMO-OFDM systems. The proposed channel estimator uses soft symbol decisions obtained by iterative detection and decoding (IDD) scheme to enhance the quality of channel estimate. Using the soft information from the decoders, the proposed channel estimator selects reliable data tones, subtracts interferences, and performs re-estimation of the channels. Authors analyze the optimal data tone selection criterion, which accounts for the reliability of symbol decisions and correlation of channels between the data tones and pilot tones. From numerical simulations, we show that the proposed channel estimator achieves considerable improvement in system performance over the conventional channel estimators in realistic MIMO-OFDM scenarios [5].

3. CHANNEL ESTIMATION:

Channel estimation is a method to characterize the impact of the physical medium on the input sequence. The key aim of channel estimation is to evaluate the impact of the channel on known or partially known group of transmittances. OFDM systems are specifically equipped for channel estimation. The sub carriers are closely spaced. The channel is estimated on the basis of the training sequence that will be known to both transmitter and receiver. The receiver can employ the known training bits and the respective received samples for estimating the channel.

3.1 LSE channel estimation

LSE estimator reduces the square error between estimation and detection to estimate channel h[m]. In matrix form, the actual output can be written as

$y=Xh$

and the error is e= is the expected output.

The square error (S) can be defined as [7]

$$
\begin{aligned}
S &= |e|^2 \\
&= (\overline{y} - y)^2 \\
&= (\overline{y} - y) * (\overline{y} - y)^t \\
&= (\overline{y} - Xh) * (\overline{y} - Xh)^t
\end{aligned}
$$

where t stands for the complex transpose of matrix. The equation can be minimized by taking its derivative w.r.t *h* and equating it corresponding to zero. The final equation is [5],

$$\overline{h} = (X^t X)^{-1} X^t y$$

where $\overline{h} = \text{hls} = X^{-1} y$.

3.2 MMSE channel estimation

The MMSE estimator minimizes the mean-square error. Mean square error = mean $(\overline{y}-y)^2 = E(\overline{y}-y)^2$. Notion of expected value and correlation can be utilized to derive the equations for locating the channel response. The estimated channel is

$$H_{mmse} = F * (R_{gY} * R_{YY}^{-1} * Y).$$

Where,

$R_{YY} = X*F*X'*F'$ + Variance of the noise * Identity matrix.

4. PROPOSED METHOD:

Firstly the data input is applied to the FEC i.e. forward error correcting code in which convolutional coding with interleaving is used .A convolutional encoder first encodes the binary input data. Coded bits are sent to interleaving and then the binary values are represented on BPSK modulator. To be able to adjust the signal in the receiver for a possible phase drift, pilot carriers can be inserted. In the Serial to Parallel block, the serial input symbol-stream is transformed into a parallel stream. These parallel symbols are modulated onto the sub carriers by applying the Inverse Fast Fourier Transform. Following the IFFT block, the parallel output is converted back again to serial and guard interval, cyclic prefix of the time domain samples, is appended to eradicate ISI. In the receivers, the guard interval is removed and the opposite processing is carried out to transmitter like time samples are converted by the FFT into complex symbols. In the channel estimation technique Enhanced iterative LMMSE algorithm is used. Demodulated symbols are block deinterleved. These bits are forwarded to Viterbi decoder. Decoded bits are going to be assigned to a specific user and then extracted utilizing the required bit rate information of the user

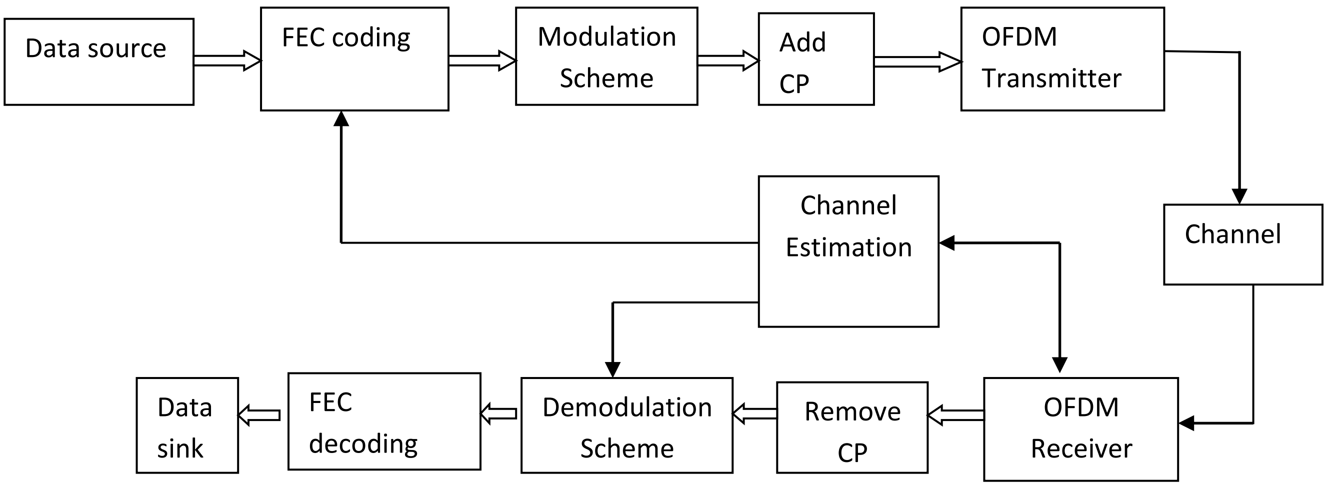


Figure 1: BLOCK DIAGRAM OF PROPOSED METHOD

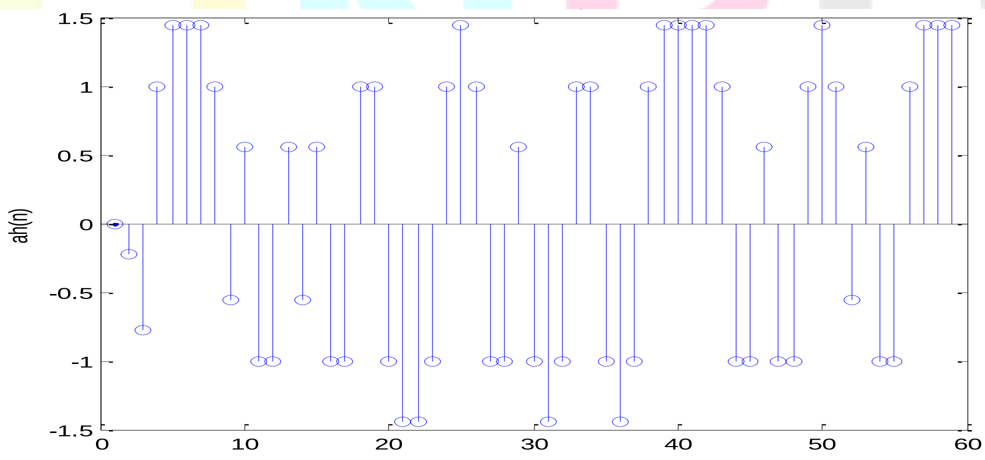
Algorithm for proposed method:
Step 1: Initialize with parameter of least square (LS) channel estimation.
Step 2: Develop the new enhanced iterative LMMSE channel estimation.
Step 3: After that iteratively develop the modified iterative LMMSE CE algorithm in which new modified LS is used.
Step 4: convergence plot is obtained.
Step 5: Finally Plot the BER v/s SNR, MSE v/s SNR & speed of convergence plot.

5. SIMULATION RESULTS:

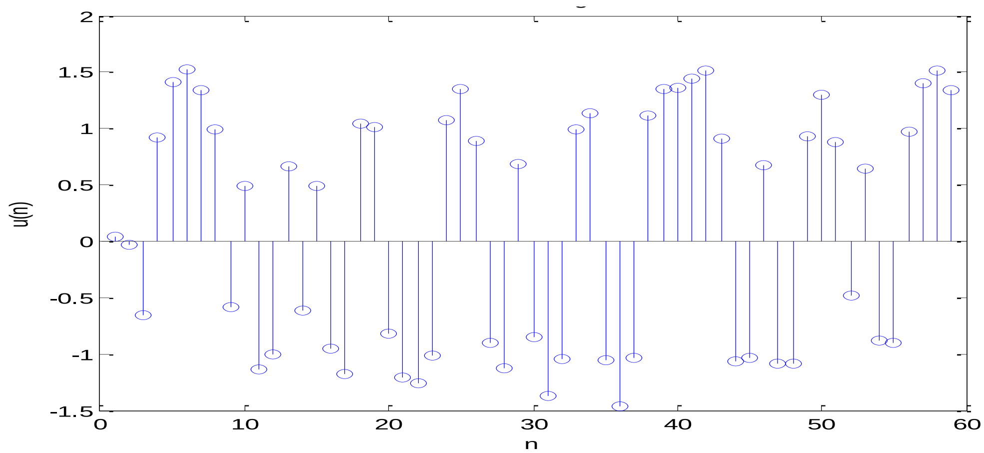
In this section, we compare the performance of the proposed channel estimation technique with the conventional approaches through computer simulations. To confirm the effectiveness of the proposed methods, two metrics, that is, MSE and BER are adopted for performance evaluation. The simulation results of comparison of transmitted signal and received signal are shown in figure (2)

TABLE 1: Simulation Parameters

S.NO.	PARAMETERS	VALUES
1.	FFT Size	64,128, 256,512
2.	CP	¼
3.	Coding	Convolutional coding
4.	Constraint length	7
5.	SNR	-15 to 15 dB
6.	Modulation	BPSK, 16 QAM, 64 QAM
7.	Code rate	1/2
8.	Channel length	4,8



a) Transmitted message



b) Received message

Figure 2: COMPARISON OF TRANSMITTED AND RECEIVED MESSAGE

5.1. Mean Square Error (MSE) Comparison of proposed algorithm between conventional Algorithm.

Figure 3 shows the MSE v/s SNR of proposed algorithm with conventional algorithm by computer simulation for different values of N= 64, 128, 256 & 512 respectively. Fig.5 shows the performance in terms of BER versus Eb/No for BPSK, 16QAM and 64QAM. Figure 4 shows the BER v/s Eb/No for BPSK modulation scheme. The figure shows that system performs better in BPSK than other modulation scheme.

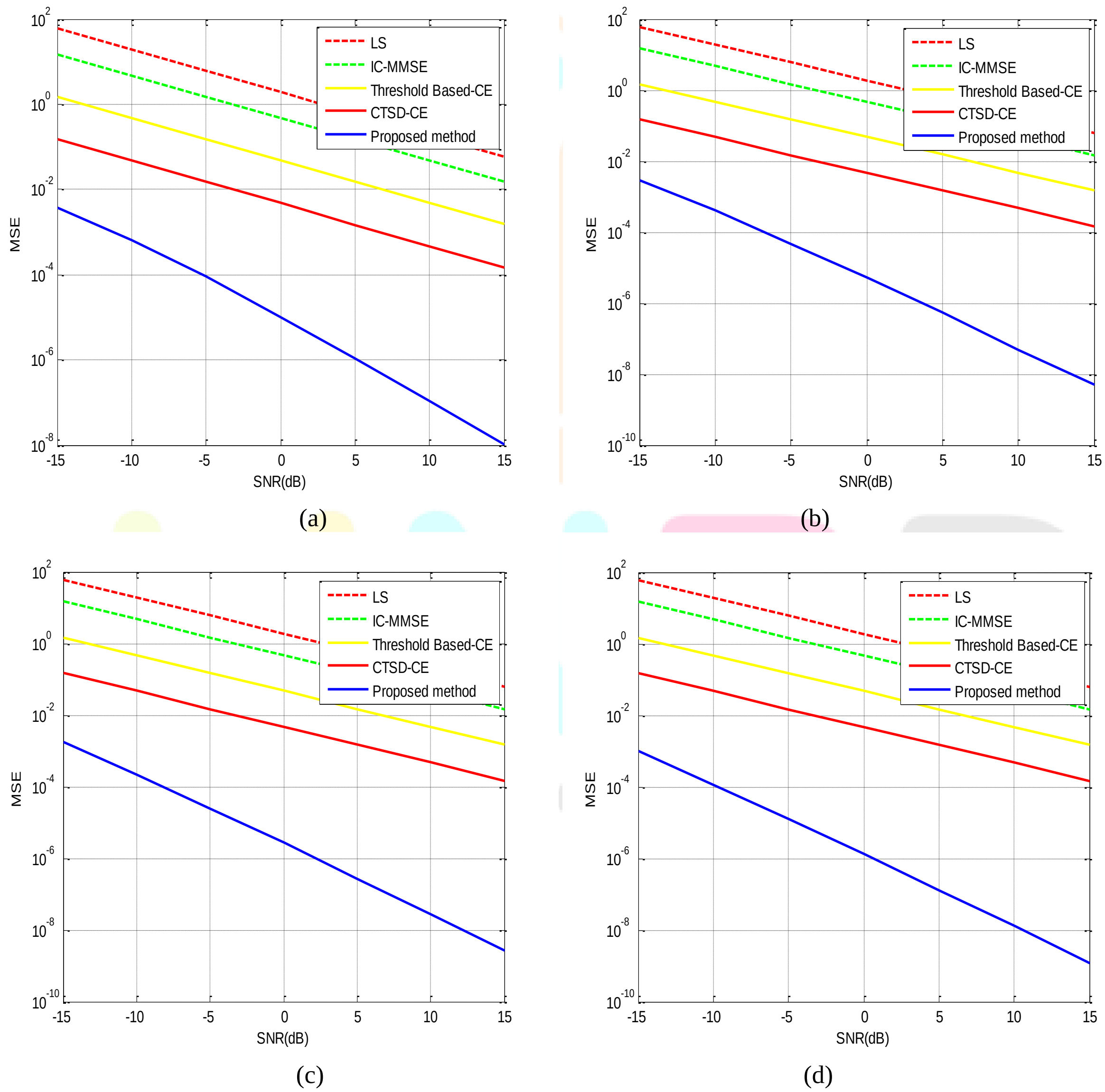


Figure 3: **MSE Plot V/S SNR** a) N= 64, L=4 & b) N= 128, L= 4, c) N=256, L= 4, d) N= 512, L=4

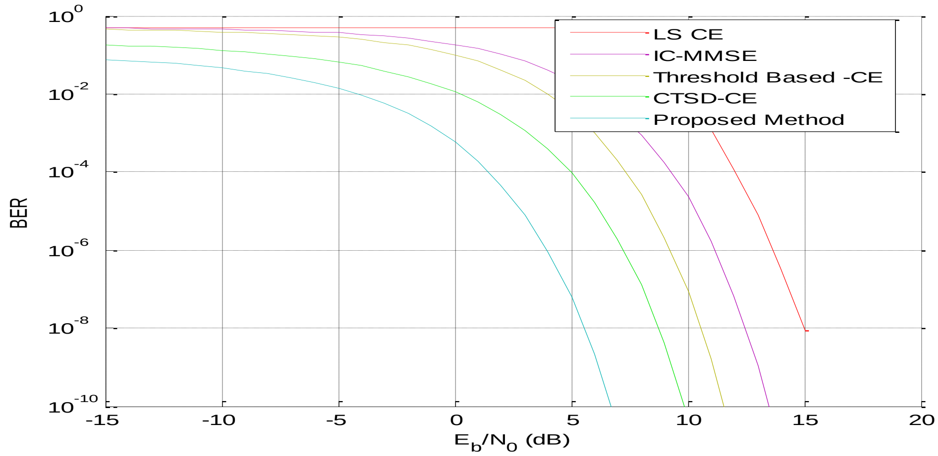


Figure 4: PLOT OF BER V/S EB/NO (DB) OF THE CONVENTIONAL AND PROPOSED METHOD FOR BPSK MODULATION SCHEME

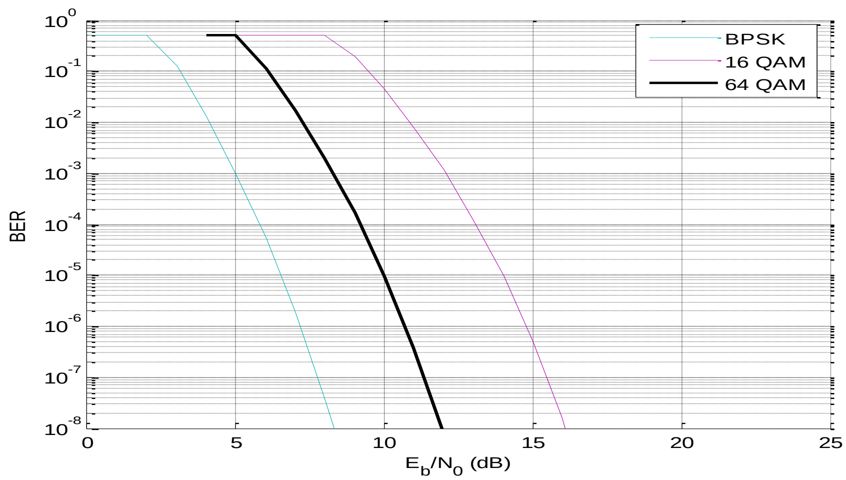


Figure 5: PLOT OF BER V/S EB/NO. FOR DIFFERENT MODULATION TECHNIQUE

6. CONCULSION:

In this paper, we introduce a new Enhanced iterative- Linear minimum mean square error (EI-LMMSE) channel estimator technique in the CC-OFDM systems. The performance can be improved by applying FEC codes in contrast to uncoded system. It is observed from simulation results that the proposed algorithm outperforms than that of other conventional algorithm. Proposed algorithm helps to transmit the data with low bit error rate with high convergence speed & low error rate in the noisy environment.

REFERENCES:

[1] SU HU et.al: "Training Sequence Design for Efficient Channel Estimation in MIMO-FBMC Systems" IEEE access Vol 5 2017.

[2] Charles U. Ndujiuba et.al: "Dynamic Differential Modulation of Sub-Carriers in OFDM" Journal of Wireless Networking and Communications 2016, 6(1): 21-28.

[3] Thamer M. Jamel: " Performance Enhancement of Smart Antennas Algorithms for Mobile Communications System" :INTERNATIONAL JOURNAL OF CIRCUITS, SYSTEMS AND SIGNAL PROCESSING Volume 8, 2014.

[4] Petros S. Bithas et.al : "An Improved Threshold-Based Channel Selection Scheme for Wireless Communication Systems" IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS, VOL. 15, NO. 2, FEBRUARY 2016.

[5] Sunho Park : ""Iterative Channel Estimation Using Virtual Pilot Signals for MIMO-OFDM Systems" IEEE TRANSACTIONS ON SIGNAL PROCESSING, VOL. 63, NO. 12, JUNE 15, 2015.

[6] Alessandro Tomasoni, Member et.al: "Efficient OFDM Channel Estimation via an Information Criterion" IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS, VOL. 12, NO. 3, MARCH 2013.

[7] Han Wang et.al: "A New Sparse Adaptive Channel Estimation Method Based on Compressive Sensing for FBMC/OQAM Transmission Network" MDPI, sensors 2016 page no. 2-12.