Development of Efficient Channel Estimation in OFDM System with DFT

Naveen Tiwari[1], Prof. Bhagwat Kakde[2], Dr. Manish Jain[3]

[1]*Mtech Scholar,* [2]*Research Guide,* [3]*HOD(ECE)*

RKDF Institute of Science and Technology, Bhopal

Abstract - In past large amount of work has been made on the past years on channel estimation in ofdm systems still it is considered as area of concern in wireless communication. A novel channel estimation technique with virtual sub carriers is proposed in this work namely a low-complexity but near-optimal DFT-based channel estimator with leakage nulling is proposed for OFDM systems using virtual subcarriers. The flow of the proposed approach is initially starts with time-domain (TD) index set estimation considering the leakage effect then followed by low-complexity TD post-processing to suppress the leakage. The proposed channel estimator approach outperforms the existing channel estimators in terms of efficiency and performance. Finally the performance and complexity of the proposed algorithm are analyzed by simulation results.

Keywords: OFDM, Channel estimation, Time domain, Wireless communications.

I. INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM) is one of the most widely used modulation technique for high-bit-rate wireless communication. Especially the wireless local area network systems such as WiMax, WiBro, WiFi and the emerging fourth-generation mobile systems are all of used of OFDM as the core modulation technique. Wireless communication systems use two different signaling schemes which are: coherent and general signaling schemes. Coherent signaling scheme such as Quadrature Amplitude Modulation (QAM) requires channel estimation and tracking of the fading channel. In a general modulation scheme such as Differential Phase Shift-Keying (DPSK) no channel estimation is required. DPSK is used for low data rate wireless transmission. For example European Digital Audio Broadcast (DAB) uses DPSK modulation scheme. For more efficient digital wireless communication systems, the coherent modulation scheme such as QAM is appropriate.

In OFDM system, the channel is usually assumed to have a finite impulse response. To avoid the inter-symbol interference, a cyclic extension is put between the consecutive blocks, where the cyclic extension length is longer than the channel impulse response.

Decision-directed and pilot-symbol-aided methods are two different ways for channel estimation. Pilot-symbol-aided channel estimation can be further divided in two types: block- type-pilot channel estimation and comb-type-pilot channel estimation. In the block-type-pilot method, all sub-carriers are reserved for the pilot within a specific period. The estimation of the channel for the block-type-pilot arrangement can be based on Least Square (LS) or on Minimum Mean Square Error (MMSE). In the comb-type-pilot method, one sub-carrier is reserved as a pilot for each symbol. The estimation of the channel for the comb-type-pilot arrangement can be based on linear interpolation, second order interpolation, low-pass interpolation or on time domain interpolation.

Figure 1.1 demonstrates the architecture of basic OFDM system having DFT and IDFT modulation.

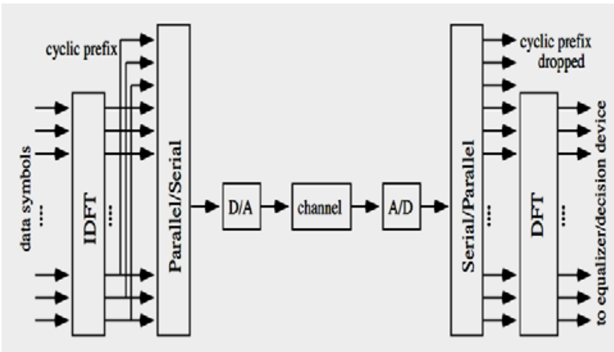

Figure 1.1 Basic OFDM system.

The main goals in developing the next generation of wireless communication systems are for delivering multimedia services such as voice, data and image in local coverage networks. These will be a complement to the existing wide area coverage systems, for example to the third generation of mobile communications. In order to provide these services, a high data rate and high quality digital communication system is required in a restricted bandwidth. A major limiting factor is, however, the multipath propagation phenomenon. It causes frequency-selective fading due to different echoes of transmitted symbols overlapping at the receiving end, which can lead to the bit-error-rate (BER) degradation. One way to effectively combat the multipath channel impairments and still provide high-data rates in a limited bandwidth is use of an orthogonal frequency-division multiplexing (OFDM) modulation method and multiple antennas at the transmitting end.

II. PROPOSED METHODOLOGY

Figure 2.1 demonstrate the system of proposed work the which outperform the existing approach of channel estimation in proposed system of OFDM channel estimation IFFT and FFT is used instead if IDFT and IFD the proposed system have the following main blocks as illustrated in figure 2.1.

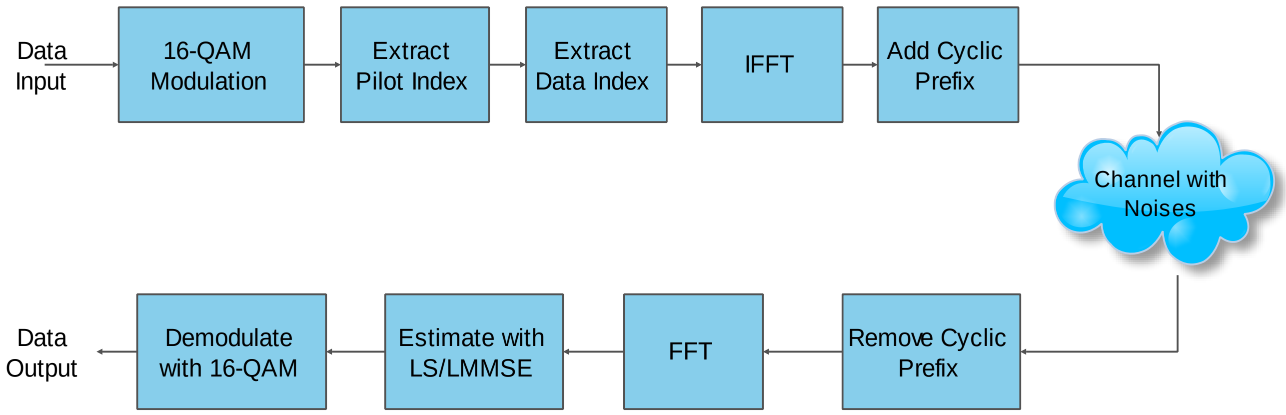

Fig. 2.1 Block Diagram of Proposed Methodology.

A. Transmitter End.

OFDM is a block transmission technique. In the baseband, complex-valued data symbols modulate a large number of tightly grouped carrier waveforms. The transmitted OFDM- signal multiplexes several low-rate data streams - each data stream is associated with a given subcarrier

a) 16 QAM modulation

Then the bits are mapped to symbols of either 16-QAM . The symbol sequence is converted to parallel format and IFFT (OFDM modulation) is applied and the sequence is once again converted to the serial format.

b) Extract Index

Index of data and pilot are extracted from signal.

c) IFFT

To convert the symbol sequence in parallel format IFFT orthogonal frequency modulation is applied on it and forwards it to add cyclic prefix.

d) Add Cyclic Prefix

Guard time provided between the OFDM symbols and the guard time filled with the cyclic extension of the OFDM symbol. Cyclic prefix work as a guard of the information signal to identify the bit sequence of information symbol.

B. Channel

Channel is a media through which the resulting RF modulated signal is transmitted. Transmitted to the receiver using the transmit antennas. Due to some channel propertied noises are added to it.

C. Receiver End

The transmitted signal is received by receiver antennas. First RF demodulation is performed and proceeded to remove cyclic prefix.

a) Remove Cyclic Prefix

The guard time is removed from each OFDM symbol and the sequence is converted to parallel format and FFT OFDM demodulation.

b) FFT

The term MMSE more specifically refers to estimation with quadratic loss function.

a) Estimate with LS /LMMSE

A minimum mean square error (MMSE) method which is applied on received serialized signal minimizes the mean square error (MSE), which is a common measure of estimator quality, of the fitted values of a dependent variable. In the Bayesian setting,

b) Demodulate with 16-QAM

Coherent signaling scheme such as Quadrature Amplitude Modulation (QAM) requires channel estimation and tracking of the fading channel. For more efficient digital wireless communication systems, the coherent modulation scheme 16 QAM is appropriate.

The received signal is in parallel format FFT is applied on to serialize the received signal output is then serialized and symbol de-mapping is done to get back the coded bit sequence.

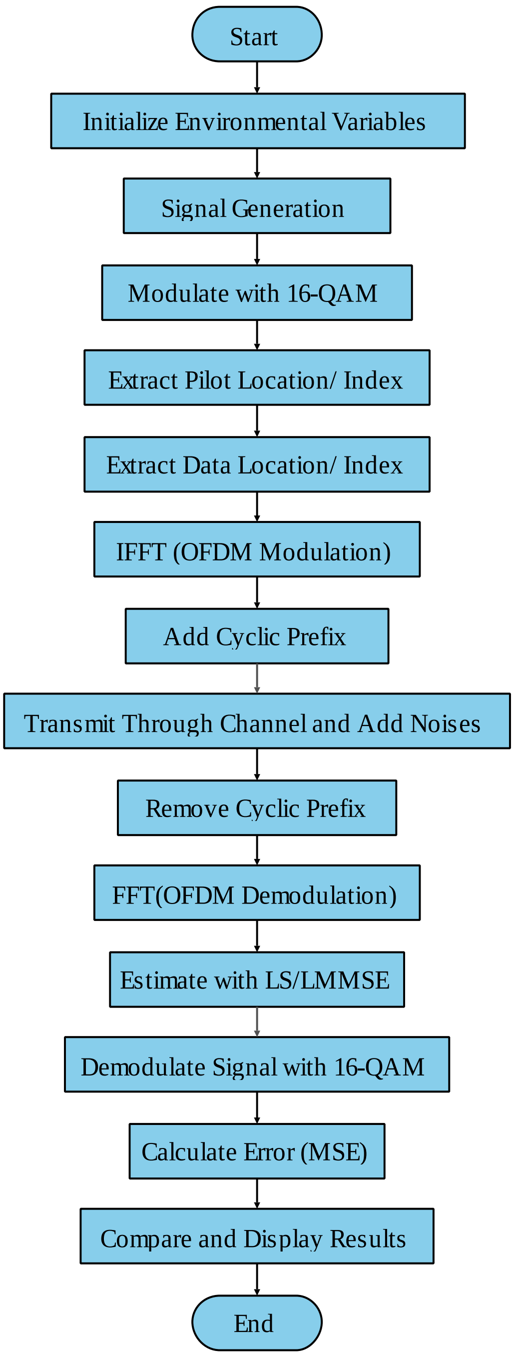

Fig. 2.1 Flow Chart of Proposed Methodology.

The flow chart of proposed methodology demonstrated in figure 2.1

III. SIMULATION RESULTS

The proposed system is simulated on the MATLAB and the mean square(MSE) performance is analysed. The MSE is calculated for the power levels from 5dBs to 25dBs.

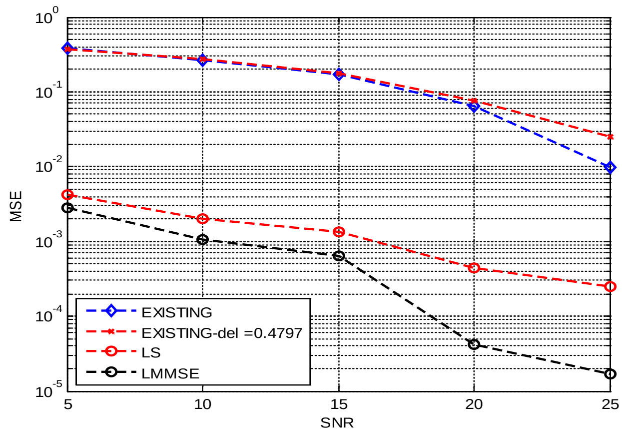

Figure 3.1: MSE performance versus SNR ρ.

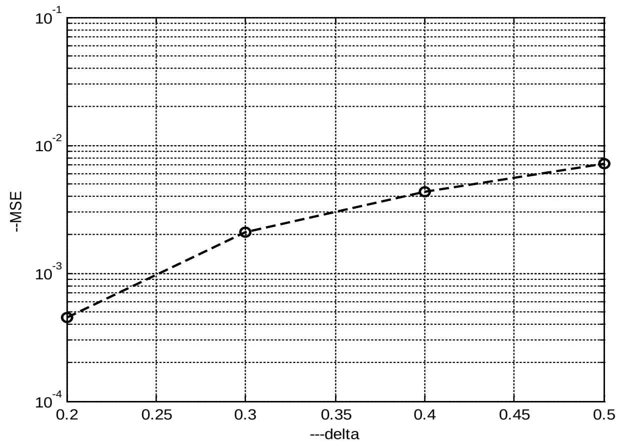

Figure 3.2: Performance of proposed method in terms of Delta vs MSE.

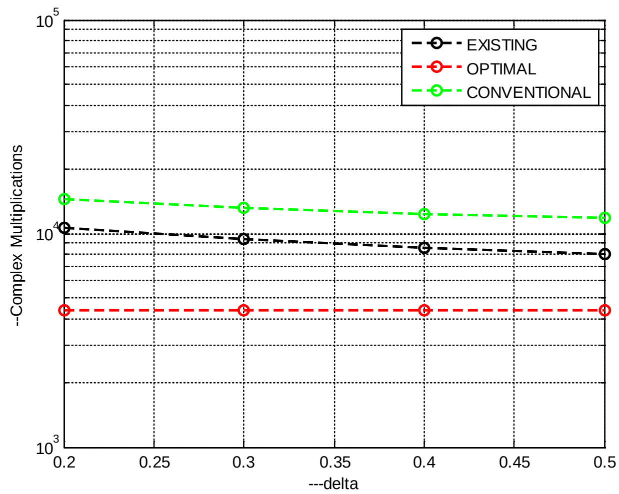

Figure 3.3: Performance of proposed method in terms of Delta vs Complex multiplications.

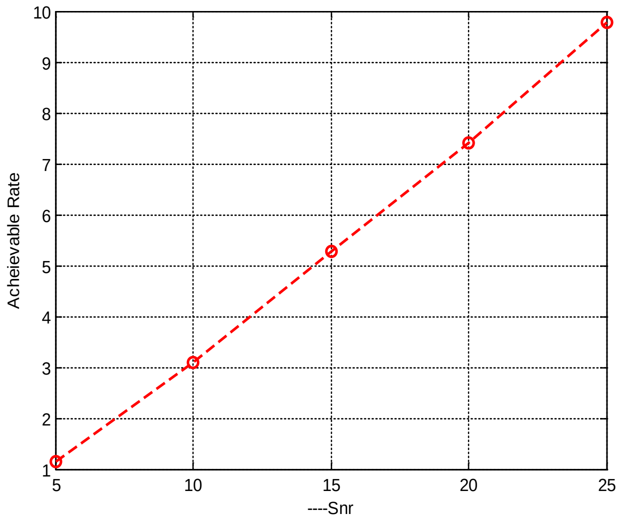

Figure 3.4: SNR achievable rate.

The system analyzed for different conditions i.e. with exiting algorithm used previously, proposed methodology with LS and LMMSE. From the simulation outcomes it can be analysed that the LMMSE technique gives lower MSE than the other one. So for the better performance of the system we should use LMMSE.

From figure 3.1 to 3.4 result of proposed system has shown and comparison of proposed system with existing system has shown in table of comparison table 3.1 under heading result comparison.

Table 3.1: Result Comparison

SNR	Mean Square Error (MSE)		
	Existing Work	Proposed Work	
		LS	LMMSE
5	0.3813	0.0041	0.00281
10	0.2647	0.0020	0.00028
15	0.1687	0.0013	$7.7x10^{-5}$
20	0.0635	$4x10^{-4}$	$3.24x10^{-5}$
25	0.0098	$2x10^{-4}$	$1.69x10^{-5}$

Channel estimation is a challenging task in the orthogonal frequency division multiplexing, in our proposed work we use estimated power delay profile algorithm for channel estimation using additive white Gaussian noise channel. Estimation of channel estimation is done by using the ETU channel for better performance and low run time complexity.

IV. CONCLUSIONS AND FUTURE SCOPE

The MIMO-OFDM gives better MSE performance over SISO – OFDM for high SNR values. MIMO channel capacity increases by a factor equal to the no. of antennas used over that of a SISO channel. MIMO system uses spatial multiplexing to increase the effective SNR of the system. The MIMO-OFDM system capacity increases with increase in diversity, i.e. no. of receivers.

The estimation techniques least square(LS) and least minimum mean square error(LMMSE) has proved to reduce the effect of noises and error during channel estimation of MIMO-OFDM. The proposed system has taken reference of modern wireless channel designed for current scenario of interference and effect of other microwave signals currently present.

The mean square error further can be improved with the slight integration of other useful techniques like digital filtering at the receiver side. Digital filtering can be anyone among infinite impulse response(IIR) filters or finite impulse response filters(FIR). The index of modulation technique will also help to improve the system signal immunity during transmission over channel.

REFERENCES

[1] K. J. Kim, H. G. Hwang, K. J. Choi and K. S. Kim, "Low-Complexity DFT-Based Channel Estimation with Leakage Nulling for OFDM Systems," in IEEE Communications Letters, vol. 18, no. 3, pp. 415-418, March 2014.

[2] M. Belotserkovsky, "An equalizer initialization algorithm for IEEE802.11a and HIPERLAN/2 receivers," in IEEE Transactions on Consumer Electronics, vol. 48, no. 4, pp. 1051-1055, Nov 2002.

[3] J. Seo, S. Jang, J. Yang, W. Jeon and D. K. Kim, "Analysis of Pilot-Aided Channel Estimation with Optimal Leakage Suppression for OFDM Systems," in IEEE Communications Letters, vol. 14, no. 9, pp. 809-811, September 2010.

[4] K. Kwak, S. Lee, J. Kim and D. Hong, "A New DFT-Based Channel Estimation Approach for OFDM with Virtual Subcarriers by Leakage Estimation," in IEEE Transactions on Wireless Communications, vol. 7, no. 6, pp. 2004-2008, June 2008.

[5] J. W. Kang, Y. Whang, H. Y. Lee and K. S. Kim, "Optimal Pilot Sequence Design for Multi-Cell MIMO-OFDM Systems," in IEEE Transactions on Wireless Communications, vol. 10, no. 10, pp. 3354-3367, October 2011.

[6] S. Rosati, G. E. Corazza, and A. Vanelli-Coralli, "OFDM channel estimation based on impulse response decimation: analysis and novel algorithms," IEEE Trans. Commun., vol. 60, no. 7, pp. 1996–2008, Jul. 2012.

[7] R. Negi and J. Cioffi, "Pilot tone selection for channel estimation in a mobile OFDM system," IEEE Trans. Consum. Electron., vol. 44, no. 3, pp. 1112–1128, Aug. 1998.

[8] M. Morelli, C.-C. J. Kuo, and M.-O. Pun, "Synchronization techniques for orthogonal frequency division multiple access (OFDMA): a tutorial review," Proc. IEEE, vol. 95, no. 7, pp. 1394–1427, Jul. 2007.

[9] J. G. Proakis, Digital Communications, 4th ed. McGraw-Hill, 2001.

[10] M. Medard, "The effect upon channel capacity in wireless communications of perfect and imperfect knowledge of the channel," IEEE Trans. Inf. Theory, vol. 46, no. 3, pp. 933–946, May 2000.

[11] I. S. Gradshteyn and I. M. Ryzhik, Table of Integrals, Series and Products, 6th ed. Academic Press, 2000.

[12] ITU-R, Guidelines for evaluation of radio transmission technologies for IMT-2000, Recommendation ITU-R M.1225, 1997.