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# A Review of OFDM Channel Estimation and Equalization Using Multi Scale Independent Component Analysis

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***Abstract*** *– In this paper a novel signal processing method based on combining the advantages of multi-scale property of wavelet transform (WT) with blind estimation capability of independent component analysis (ICA), called, a multi-scale ICA (MS-ICA) has been planned to estimate the channel characteristics. In this paper an improved channel estimation algorithm for orthogonal frequency-division multiplexing mobile communication systems. Present day wireless communication systems require a high data rate wireless access, for which the prerequisite is larger bandwidth.*

***Keywords****: Channel Equalization; Wavelet Transform; Orthogonal Frequency Division Multiplexing; Independent Component Analysis; Multi-scale Independent Component Analysis,*

## I. Introduction

Orthogonal frequency division multiplexing (OFDM) is an increasingly popular multicarrier modulation technique, mainly because of its ability to combat multipath effects in wireless communication systems. It has been implemented in several wire line and wireless high-speed data communications standards (ADSL [6], IEEE 802.11 [6], HiperLAN) and has been adopted by the European digital audio and video broadcasting standards (DAB and DVB). [6] Wireless communication system requires an effective communication technique which should combat the shortcomings produced by the high data rate and high bandwidth systems. The main problem with high data rate systems over a frequency selective fading channel is inter symbol interference (ISI), which can be easily eliminated by the use of spectral efficient orthogonal frequency division multiplexing (OFDM) [1]. The advantages of OFDM system makes it a way to important applications in third, fourth generation wireless communication systems, military, commercial applications, wireless LANs and WiMAX. [1]

Orthogonal frequency-division multiplexing (OFDM) is generally known as an effective technique for prime bit rate applications like digital audio broadcasting (DAB), digital video broadcasting (DVB), and digital high-definition television (HDTV) broadcasting, since it will stop inter-symbol interference (ISI) by inserting a guard interval and may mitigate frequency selectivity of a multipath channel using a simple one-tap equalizer [2]. In an OFDM system, though the degree of channel variation over the sampling amount becomes smaller as data rates increase, the time variation of a fading channel over an OFDM block period causes a loss of sub channel orthogonality, resulting in an error floor that increases with the Doppler frequency. The performance degradation due to the inter-channel interference (ICI) becomes significant as the carrier frequency, block size, and vehicle rate increase. The time-domain compensation technique, which can reduce the fading distortion in a flat (not frequency selective) Rayleigh fading channel by correcting gain and part distortions of the received time-domain signal using a pilot symbol, is proposed. In [2], the frequency domain equalization technique is proposed to catch up on the fading distortion with less noise improvement in an exceedingly flat Rayleigh fading channel. [2]

In Recent years, there has been a lot of interest in applying orthogonal frequency-division multiplexing (OFDM) in wireless and mobile communication systems due to its numerous advantages in lessening the severe effects of frequency-selective fading [1]. However, the high-rate and spectrum efficient OFDM systems employing multilevel modulation schemes with no constant amplitude (e.g., 16QAM generally require estimation and tracking of the fading channel parameters to perform coherent demodulation. [3]

## II. Literature Survey

E. Hari Krishna et. al [1] “OFDM Channel Estimation and Equalization Using Multi Scale Independent Component Analysis”, in this paper author proposed In order to nullify the effect of inter symbol interference (ISI) caused by the high data rate, high bandwidth wireless communication systems, the orthogonal frequency division multiplexing (OFDM) has proven to be a best solution, which leads it to numerous applications in third generation, fourt generation and WiMAX applications. In this paper, a novel signal processing based on multi-scale independent component analysis (MS-ICA), by combining the attractive properties of wavelet transform (WT) and independent component Analysis (ICA) is utilized for OFDM channe estimation and equalization. The bit error rate (BER simulation results established the fact that the proposed MSICA method is superior as compared to other established methods.

Won Gi Jeon et. al [2] “An Equalization Technique for Orthogonal Frequency-Division Multiplexing Systems in Time-Variant Multipath Channels”, in this paper author proposed The conventional frequency-domain equalizer with one tap in an OFDM system compensates for the frequency-selectivity of a multipath fading channel, assuming that the channel is stationary over the period of an FFT block. In this paper, a new frequency-domain equalization technique to reduce the time-variation effect of a multipath fading channel is described by assuming that the CIR varies in linear fashion during a block period. It is shown through simulation that the loss of orthogonality caused by the time-variation of a multipath fading channel can be compensated effectively by the proposed equalizer if the relative Doppler frequency change is in the range of $(0.005 < \Delta f_D < 0.1)$. It is also shown that improved BER results can be obtained with the proposed approach by compensating for the multiplicative distortion and for the ICI from only a few neighboring sub channels.

Baoguo Yang et. al [3] “Channel Estimation for OFDM Transmission in Multipath Fading Channels Based on Parametric Channel Modeling”, in this paper author proposed an effective channel estimation algorithm using the pilot subcarriers for the sparse multipath fading channels. This algorithm is based on the use of a parametric channel model. The use of such model can effectively reduce the signal subspace dimension of the channel correlation matrix and, consequently, improve the channel estimation performance. The simulation results show that the MDL criterion and the ESPRIT method can adaptively estimate the initial channel parameters. Further, the IPIC DLL is shown to be an effective way to estimate and track the multipath time delays. Analysis and simulation results also demonstrate that the proposed channel estimation algorithm gives a substantial performance improvement in MSE over the nonparametric channel model-based methods.

Leonard J. Cimini et. al [4] “Analysis and Simulation of a Digital Mobile Channel Using Orthogonal Frequency Division Multiplexing”, in this paper author proposed r mobile radio system based on orthogonally frequency division multiplexing many low-rate sub channels into one higher rate channel was analyzed and simulated. This technique, when used with pilot-based correction, was shown to provide large improvements in BER performance in a flat Rayleigh fading environment. Degradations due to severe delay spread were kept to a minimum by frequency interpolation of two pilots: Using a frequency offset scheme for the pilots limited the effects of cochannel pilot interference. These considerations provided very' good BER performance; at the expense of a decrease in the overall bandwidth efficiency. The averaging ability of the OFDM system, which makes' the bursty Rayleigh channel appear nearly Gaussian, provides this large BER improvement. Additional improvements are possible if larger signaling intervals are permissible.

Lei Wei et. al [5] “Synchronization Requirements for Multi-user OFDM on Satellite Mobile and Two-path Rayleigh weakening Channels”, during this paper author proposed The performance of a new multiple access modulation concept, multi-user OFDM with time raised cosine pulse shaping, has been analyzed on the satellite mobile channel and the two path Rayleigh channel. The results show that with estimation accuracies of timing and frequency, dTj<4%, and dFi<2%, on Gaussian and typical Rician channels, the results of multi-user ACI on the performance of the system with β=0.2 are minor. If dTj<2%, and dFi<2%, the error floors of the OFDM uplink with β=0.2 is less than $10^{-3}$ OFDM does not need root Nyquist filtering and is less affected by the multipath time delay, but slightly more severely affected by the Doppler frequency shift than FDM with root Nyquist filtering for the same value of β. N on-zero frequency offset or shift will cause interference from only two adjacent channels for FDM using root Nyquist filtering, which is way but the interference from over ten adjacent users. For the non-zero timing offset or shift this is the other way around.

Samuli Tiiro et . al [6] “ Implementation of the least squares channel estimation algorithm for MIMO-OFDM Systems .”In this paper the least squares(LS) channel estimation algoritm for a multiple input multiple output(MIMO) system with orthogonal frequency divison multiplexing(OFDM) is considered . Two architectures for the algorithm are presenred and the architectures are implemented using fixed point arithmetic . The minimum word lengths for the implementations are determined through computer simulations for 2×2 and 4×4 MIMO systems with quadrature phase shift keying (QPSK) modulation. Field programmable gate array (FPGA) synthesis simulation is done for the architectures using the obtained word lengths which provide complexity and latency results .The algorithm implementations are shown to consume reasonably small amount of hardware resources.

# III. Method

### *III.1. Orthogonal Frequency Division Multiplexing*

In wireless communication, multipath radio channels often leads to frequency selective fading's and serious inter symbol interference (ISI) for high speed data transmissions. The OFDM techniques have been widely employed to combat multipath interference at high data rate. Channel estimation is essentially a process to recover channel impulse response and it is an important part of OFDM transmission system. Multipath channel and large no. of pilots are required in the traditional channel estimation methods like least squares(LS) and minimum mean squared error 9MMSE) which reduces frequency spectrum utilization. Orthogonal Frequency Division Multiplexing or OFDM may be a modulation format that's getting used for several of the latest wireless and telecommunications standards. OFDM has been adopted at intervals the Wi-Fi arena where the standards like 802.11a, 802.11n, 802.11ac and a lot of. It's additionally been chosen for the cellular telecommunications customary LTE / LTE-A, and in addition to this it has been adopted by different standards like WiMAX and lots of a lot of. Fig1 shows the block diagram of an OFDM system.

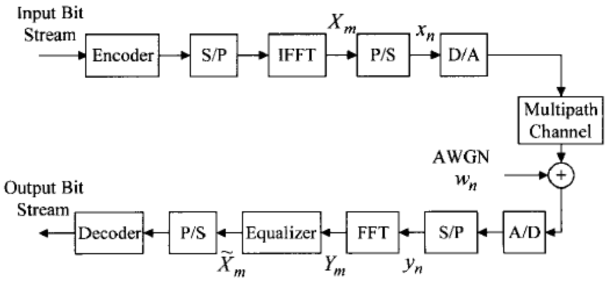


Fig.1 A baseband block diagram for an OFDM system

OFDM may be a sort of multicarrier modulation. AN OFDM signal consists of kind of closely spaced modulated carriers. Once modulation of any kind - voice, data, etc. is applied to a carrier, and then side bands detached either aspect. It's necessary for a receiver to be ready to receive the entire signal to be able to successfully demodulate the information. Fig2 shows the traditional view of receiving signals carrying modulation. As a result once signals are transmitted close to one another they have to be spaced that the receiver can separate them using a filter and there should be a guard band between them. this cannot be the case with OFDM. Though the sidebands from each carrier overlap, they will still be received whereas not the interference that may be expected because they are orthogonal to every other sub carriers. This can be achieved by having the carrier spacing equal to the reciprocal of the image period.

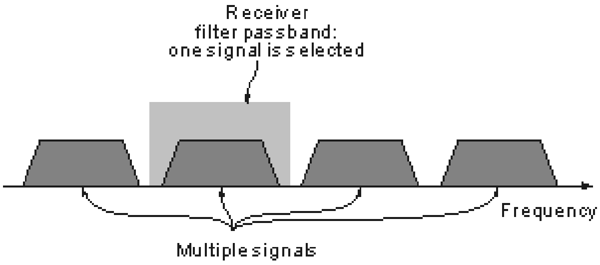


Fig.2 Traditional view of receiving signals carrying modulation

To see however OFDM works, it's necessary to look at the receiver. This acts as a bank of demodulators, translating each carrier right down to DC. The following signal is integrated over the image period to regenerate the information from that carrier. A similar demodulator in addition demodulates the other carriers. as a result of the carrier spacing capable the reciprocal of the image amount means they will have a full variety of cycles within the symbol period and their contribution will total to zero - in numerous words there is no interference contribution.

One demand of the OFDM transmitting and receiving systems is that they need to be linear. Any non-linearity will cause interference between the carriers as results of inter-modulation distortion. This can introduce unwanted signals that may cause interference and impair the orthogonality of the transmission.

Orthogonality can be achieved by carefully selecting the sub-carrier frequencies. One of the ways is to select sub-carrier frequencies such that they are harmonics to each other.fig3 shows the OFDM spectrum.

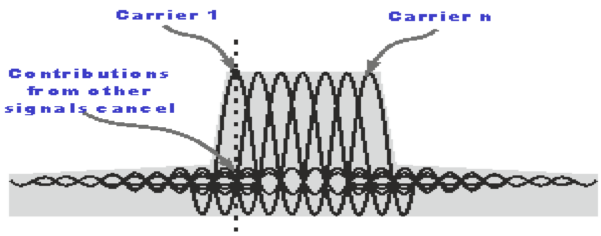


Fig.3 OFDM Spectrum

# IV. Conclusion

This paper has reviewed the mainly latest research trends and proposed the MS-ICA method. To nullify the effect of inter symbol interference (ISI) caused by the high data rate, high bandwidth wireless communication systems; the orthogonal frequency divison multiplexing (OFDM) has proven to be the best solution. This review paper presented after refering various technical papers and literature on OFDM Channel Estimation and Multi Scale independent component Analysis.

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