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A Review on Different Schemes to Remove ICI in OFDM System

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ABSTRACT: Orthogonal Frequency Division Multiplexing (OFDM) is a multi-carrier modulation technique which divides the spectrum into multiple carriers. But due to Doppler shift of the channel or due to mismatching between the transmitter and receiver local oscillator frequencies, the effect of frequency offset occurs in OFDM which results in loss of orthogonality among the sub-carriers and produce Inter-Carrier Interference (ICI). Many researchers have proposed various techniques to reduce the ICI in OFDM systems. In this paper, the study of different reduction ICI techniques is presented.

KEYWORDS: OFDM, ICI, Time domain windowing, Pulse shaping, Maximum like hood estimation, ICI self cancellation method.

I.INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM) is a widely known modulation scheme in which a serial data stream is divided into parallel streams that modulate a group of orthogonal subcarriers [1]. OFDM is a method of encoding digital data on multiple carrier frequencies. An OFDM signal consists of a number of closely spaced modulated carriers. When modulations of any voice or data signal are applied to a carrier, then sidebands spread out either side. It is essential for a receiver to be capable to receive the entire signal and successfully demodulate the data. OFDM is broadly used and considered a promising technique for high speed data transmission in, wired-based Asymmetric Digital Subscriber Line (ADSL), IEEE 802.16 WiMax for broadband metropolitan area network, IEEE 802.11a/g local area network (WLANs), digital broadcasting and 4G mobile communications. However Doppler frequency shift and multipath fading effects the sensitivity of OFDM system, due to which orthogonality of the carriers is no longer maintained and results in Inter-Carrier Interference (ICI). In this paper, the various techniques which includes Pulse shaping, Time domain windowing, Frequency domain equalization, ICI self cancellation technique, Maximum Likelihood Estimation (MLE), Extended Kalman Filtering (EKF) have been discussed to overcome the effects of Inter-Carrier Interference (ICI). In Section II, a brief description of OFDM system model is discussed, Section III covers the various ICI reduction techniques and Section IV concludes the paper.

II.SYSTEM MODEL AND ASSUMPTIONS

The basic OFDM system includes high speed input data, serial to parallel transmission, modulation and multiplexing scheme, parallel to serial transmission, channel, demodulation scheme, IFFT and FFT as shown in Figure 1. Firstly, the input data stream is converted into parallel data stream and then mapped with desired modulation scheme. Further, the symbols are mapped with Inverse Fast Fourier Transform (IFFT) and converted to serial stream. The entire OFDM symbol is then transmitted through the channel. At receiver end these symbols are converted back to parallel stream and mapped with FFT scheme.

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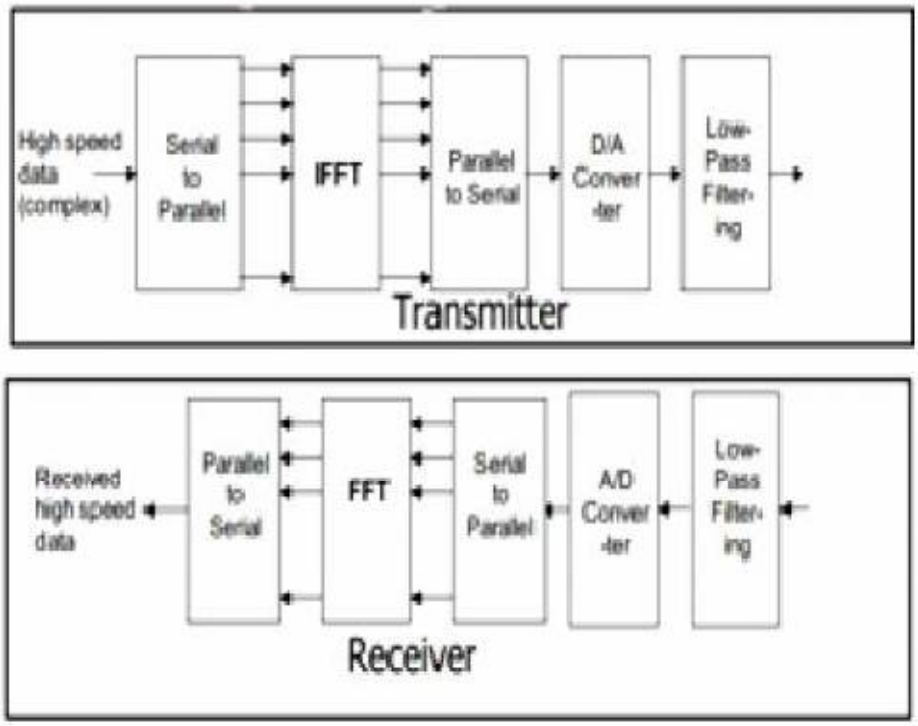

Fig. 1 Basic block diagram of OFDM System

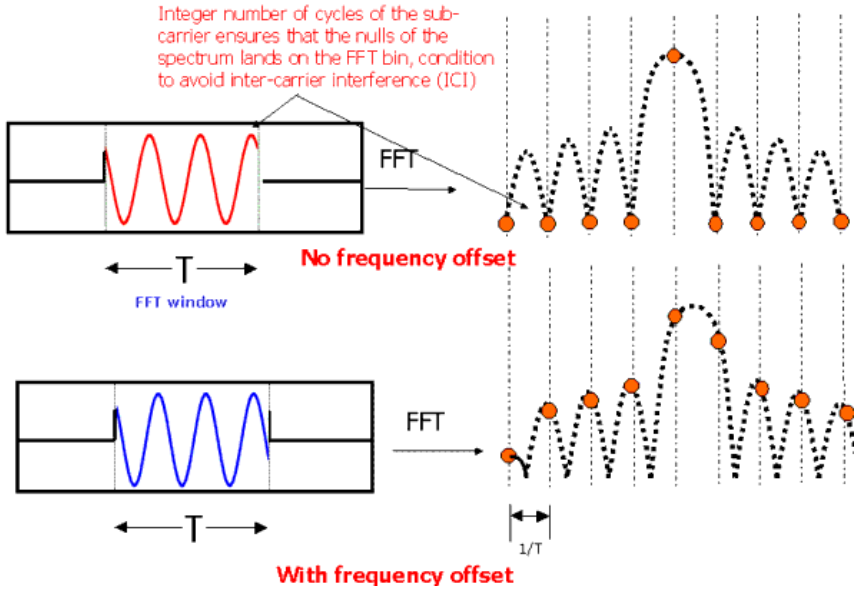

Fig. 2 Basic frequency offset of OFDM System

Then the symbols are mapped with demodulation scheme and converted to serial data as output data. Before the demodulation of sub-carriers at the OFDM receiver, at least two synchronization tasks have been performed. The first one is to locate the symbol boundaries and the optimal timing instants to reduce the effects of Inter-Carrier Interference (ICI) and Inter-Symbol Interference (ISI). The other one is to estimate and correct the carrier frequency offset of the

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received signal to avoid the ICI. Generally, the OFDM received signal has a frequency offset, which instantly results in ICI.

III. ICI CANCELLATION METHODS

Time Domain windowing

Windowing is a popular method of reducing the spectral side lobes of OFDM. Thus, the effect of ICI in OFDM is reduced by significant time windowing of the signal. Due to the tapered and smooth edges, the Raised Cosine (RC) window is generally used to reduce the effect of ICI in OFDM system. In this a window function is multiplied with the transmitted signal waveform. In order to receive the same transmitted signal, the same window is used on the receiver side. This method can only reduce the ICI if the channel is band limited. However, windowing does not deal with the Doppler shift and the frequency mismatch between the transmitter and the receiver. So, this method is not an efficient method.

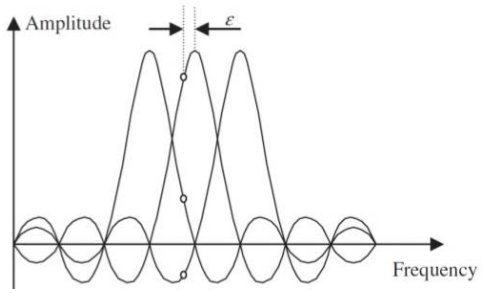

Fig. 3 Basic frequency offset with ICI of OFDM System

Maximum Likehood Estimation

This method of ICI reduction was suggested by Moose. In this method the frequency offset is first statistically estimated using a Maximal likelihood algorithm and then cancelled at the receiver. In this the OFDM symbol is replicated and comparison of the phases of each of the subcarriers between the successive symbols is done before transmission. If the value of frequency offset is predicted, then the ICI distortion in the data symbols is reduced by multiplying the received symbols with a complex conjugate of the frequency shift and applying the FFT which is given as:

$$X(n) = FFT\{Y(n)e^{-j2\pi\varepsilon n/N}\}$$

Pulse Shaping

In OFDM system, each carrier signal has one main lobe followed by number of side lobes having decreasing amplitude. Since at the peak value of each carrier spectral null exits and there is no loss of orthogonality among carriers. However, during frequency offset the spectral null does not correspond to the peak value of the individual carrier due to which loss of orthogonality occurs and some power of the side lobes exists at the centre of the individual carriers which is known as ICI power. If the frequency offset increases then the value of ICI power will also increase. So, the main purpose of pulse shaping is to reduce the amplitude of side lobes which leads to the significant decrease in the ICI power. Therefore, a number of pulse shaping functions have been proposed to reduce the side lobe. The major pulse shaping functions are Rectangular pulse (REC), Raised cosine pulse (RC), Sinc power pulse (SP), Improved Sinc power pulse (ISP).

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ICI Self-Cancellation Method

In single carrier communication system, phase noise basically produces the rotation of signal constellation. However, multi-carrier OFDM system is very vulnerable to the phase noise or frequency offset which results in Inter-Carrier Interference (ICI). The orthogonal characteristics between subcarriers are easily affected by this ICI which considerably degrades the system performance. The general idea of ICI self-cancellation scheme is to modulate one data symbol onto a group of sub-carriers with predefined weighting coefficients. If 1st sub carrier is modulated with data symbol 'x' then the 2nd sub-carrier is modulated with data symbol '–x' so that the ICI generated between the two sub-carriers mutually cancels each other. This method is easy, less complex and effective for both flat channels and multipath fading channels respectively. Data conversion method and data-conjugate method stand out to be the ICI self-cancellation technique. The main drawback of this method is the reduction in bandwidth efficiency as same symbol occupies two sub-carriers.

IV.LITRATURE REVIEW

In April 2015 Vaibhav Chaudhary: MIMO OFDM system is very popular now days in the field of communication system supporting Multimedia transmission over limited Bandwidth requirement. It is emerged as very reliable, fast and accurate in field of Data transmission over various fading channel. Along with enormous advantages in this system there are some limitations which affect the performance of the system. One of the disadvantages is Inter carrier Interference which generates due to Frequency offset and Doppler delay spread between transmitter and receiver. It severely affects the quality of performance if not minimized properly. In this paper a unique approach named Pulse shaping is being applied with conventional MIMO OFDM system for minimization of Inter Carrier Interference

In November 2015 Sukhjit singh: Orthogonal Frequency division multiplexing (OFDM) is promising technique for broadband wireless communication system. Intercarrier interference (ICI) occurs in OFDM which must be removed. There are various methods to reduce ICI in OFDM. In this paper we will discuss these various methods like maximum likelihood Estimation (MLE), self cancellation (SC), Extended Kalman filtering (EKF), Time domain window, frequency domains window techniques, and channel estimation techniques.

In July-2015 K. Himaja, M. Ranjith Kumar: In Today‟s world OFDM plays very important role for wireless communication systems. OFDM has over lapping subcarrier spectrum [1] due to this overlapping spectrum OFDM has very high spectral efficiency. OFDM is also known as Multi carrier modulation technique and this OFDM system is very sensitive to carrier frequency offset [1,2], which cause loss of orthogonality and amplitude reduction of OFDM signal and lead to Inter Carrier Interference(ICI)[2] ,which is one of the major weakness of OFDM system. In this paper various ICI reduction techniques are discussed. Techniques like Time domain windowing, Frequency domain equalization, Maximum likelihood estimation (MLE), Extended kalman filtering (EKF) and ICI self cancellation technique.

In December 2014 Shilpi Gupta, Upena Dalal, and Vishnu Narayan Mishra: In orthogonal frequency division multiplexing (OFDM) system, the existence of frequency offset in AWGN channel affects the orthogonality among the subcarriers and consequently introduces the intercarrier interference (ICI). The paper investigates new ICI self-cancellation technique to mitigate the effect of ICI in FFT-OFDM and compares it to DCT based OFDM system in terms of bit error rate (BER) and carrier to interference ratio (CIR). The proposed method for group size three results in a significant 20 dB improved CIR in FFT-OFDM. In terms of BER, proposed ICI self-cancellation technique outperforms the other self-cancellation techniques in FFT-OFDM. Also, this paper investigates outperforming BER and CIR improvement by using DCT-OFDM without applying self-cancellation techniques, due to its energy compaction property.

June 2015 Arvind Kumar, Rajoo Pamdey: Intercarrier interference (ICI) is a major problem of orthogonal frequency division multiplexing (OFDM) systems. The difference between transmitter and receiver local oscillator frequencies results ICI in OFDM systems. Self-ICI cancellation is a simple and effective scheme to cancel the effect of ICI. A number of variants of Self-ICI cancellation schemes, like simple self, DFT-based ICI cancellation, conjugate cancellation (CC), and phase rotated conjugate cancellation (PRCC) schemes are studied in this paper. The throughput

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of all these schemes is same. Simulation results show that the bit error rate (BER) performance of PRCC scheme is much better than the other schemes under high frequency offset environment. However, carrier to interference ratio (CIR) of CC is better than other schemes for low value of frequency offset.

In January 2015 Vaibhav Chaudhary Rakesh Mandal: The vast usage of mobile applications have emerged a need for high speed data transmission and efficient and error free data transmission. For the purpose the use of multiple antenna systems at both the transmitting and receiving end is formulated known as MIMO Systems. It provides improved Spectral Efficiency and link reliability as compared to conventional systems. When it is combined with OFDM systems; it eliminates the fading effect and with requirement of lower Bandwidth it provides high Throughput. Yet having a number of advantages; it suffers from some limitations like ISI, ICI and PAPR. These are the factors which degrades the System Performance.

In June-2015 Manpreet Saini, Prabhjot Singh: Orthogonal frequency-division multiplexing (OFDM) effectively mitigates intersymbol interference (ISI) caused by the delay unfold of wireless channels. The rise within the range of wireless devices and also the demand for higher information rates places an increasing demand on information measure. This necessitates the requirement for communication systems with redoubled turnout and capability. Multiple input multiple output orthogonal frequency division multiplexing (MIMO-OFDM) is a way to satisfy this would like. OFDM is employed in several wireless communication devices and offers high spectral potency and resilience to multipath channel effects. Therefore, it's been utilized in several wireless systems and adopted by varied standards. During this paper, we tend to gift a comprehensive survey on OFDM for wireless communications techniques for receiver planning as references.

V.CONCLUSION

In this paper, the survey of different techniques to reduce the effect of ICI in OFDM system is performed. Among all the reduction techniques of ICI, ICI self-cancellation proved to be the best technique since it does not require channel estimation and is simple in implementation, i.e., less complexity and effective whereas Pulse shaping and Maximal likelihood estimation method involves complexity in implementation.

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