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PERFORMANCE IMPROVEMENT OF OFDM SYSTEM BY USING ICI SELF CANCELLATION TECHNIQUE

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ABSTRACT: OFDM is the expected performance for 4th Generation broadband multimedia wireless systems. OFDM is robust to multi-paths fading and delay because it has high data transmission capability with high bandwidth efficiency that's why it has recently been applied in wireless communication systems. the causes of loss of orthogonality and amplitude reduction of OFDM signal and lead to Inter Carrier Interference (ICI) is due to OFDM system is very sensitive to carrier frequency offset, which is one of the major drawback of OFDM system. We can reduce ICI by using various techniques. Here in this paper ICI self cancellation method is used to combat the effect of ICI induced by CFO

Keywords- OFDM, ICI, CFO

I.INTRODUCTION

In today's world OFDM is very functional for high speed data transmission systems, because it has numerous unique features like Robustness to multipath fading, high spectral efficiency, and immunity to impulse interference, flexibility and simple equalization over single carrier communication system.

OFDM is a special case of multi-carrier modulation. Multi-carrier modulation is the concept of splitting a signal into a number of signals, modulating each of these new signals to several frequency channels, and combining the data received on the multiple channels at the receiver [2]. In OFDM, the multiple frequency channels, known as sub-carriers, are orthogonal to each other [3]. But one of the major weakness of OFDM system is loss of orthogonality. The causes of loss of orthogonality and amplitude reduction of OFDM signal and lead to ICI because OFDM system is very sensitive to carrier frequency offset [2], which result from Doppler shift in the channel or by difference between the Transmitter and Receiver local oscillator frequency, this ICI destroy the orthogonality of the spectrum and signal can't be received without interference.

The problem of ICI can be solved by various techniques proposed by various researchers which include Time domain windowing, Frequency domain equalization, Maximum Likelihood estimation (MLE), Extended, Pulse Shaping and ICI self cancellation technique.

This paper discusses all the prominent ICI reduction technique described above. The rest paper is organized as follows section II. Discusses OFDM system model and section III describes mechanism of ICI .section IV describes ICI self cancellation technique and in section V conclusion is given.

II. OFDM SYSTEM MODEL

A basic OFDM system contains modulation scheme, serial to parallel transmission, parallel to serial transmission and IFFT/FFT. Fig.1, illustrate the block diagram of OFDM system. The input data stream is converted into parallel data stream and mapped with modulation scheme. Then the symbols are mapped with Inverse Fast Fourier Transform (IFFT) and converted to serial stream. The complete OFDM symbol is transmitted through the channel

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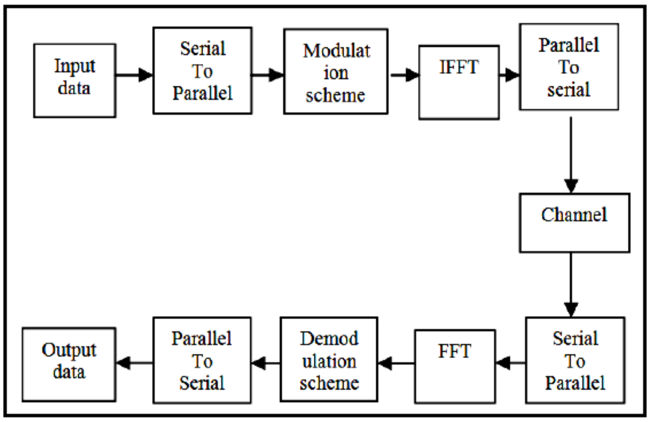

Fig 1: Block Diagram of FFT Based OFDM System

Therefore OFDM symbol can be expressed as

$$x(n) = \frac{1}{N}\sum_{m=0}^{n-1} X(m)e^{j2\pi nm/N} \quad (1)$$

Where x (n) denotes the sample of the OFDM signal, X(m) denotes the modulated symbol within subcarrier and N is the number of subcarriers. On receiver side this symbol are converted back to parallel stream and mapped with FFT then with demodulation scheme and converted to serial data as output data.

The demodulated symbol stream is given by

$$y(m) = \sum_{n=0}^{N-1} y(n)e^{-j2\pi nm/N} + w(m) \quad (2)$$

Where w (m) corresponds to the FFT of the samples of the $w(n)$

III.ANALYSIS OF ICI

The main difficulty with OFDM, is its vulnerability to small differences in frequency at the transmitter and receiver, normally referred to as frequency offset, caused by Doppler shift due to relative motion between the transmitter and receiver, or by differences between the frequencies of the local oscillators at the transmitter and receiver

The received signal is given by,

$$y(n) = x(n)e^{\frac{j2\pi n\varepsilon}{N}} + \omega(n) \quad (3)$$

Where ε represents the normalized frequency offset, that is $\varepsilon = \Delta f/(\frac{1}{NT})$ where Δf where is the frequency difference between the transmitter and the receiver, and NT denotes the interval of an FFT, w(n) is the AWGN introduced in the channel and T is the subcarrier symbol period. The effect of the channel frequency offset on the received symbol stream can be understood by considering the received symbol Y (K) on the K^{th} sub-carrier. In an OFDM communication system, assume, ε is channel frequency offset, the received signal on subcarrier k can be written as

$$Y(K) = X(K)S(0) + \sum_{l=0,l\neq K}^{N-1} X(l)S(l-K) + n_K \quad (4)$$

K=0,1,.........N-1

Where N is the total number of the subcarriers, *X*(*k*) denotes the transmitted symbol n_K is an additive noise sample. *S* (*l*-*k*) is the complex coefficients for the ICI components in the received signal. The sequence *S* (*l*-*k*) is defined as the ICI coefficient between l^{th} and K^{th} subcarriers, which can be expressed as

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$$S(l-K) = \frac{\sin(\pi(1+\varepsilon-K))}{N\sin(\pi(l+\varepsilon-K)/N)}\exp(j\pi(1-\tfrac{1}{N})(l+\varepsilon-K)) \quad (5)$$

The first term in the right-hand side of (4) represents the desired signal. The second term is the ICI components. To analyse the effect of ICI on the received signal, we consider a system with N=32 carriers. The frequency offset values used are 0.4 and 0.8,The complex ICI coefficients S(l-k) are plotted for all sub-carrier indices in Figure 2.

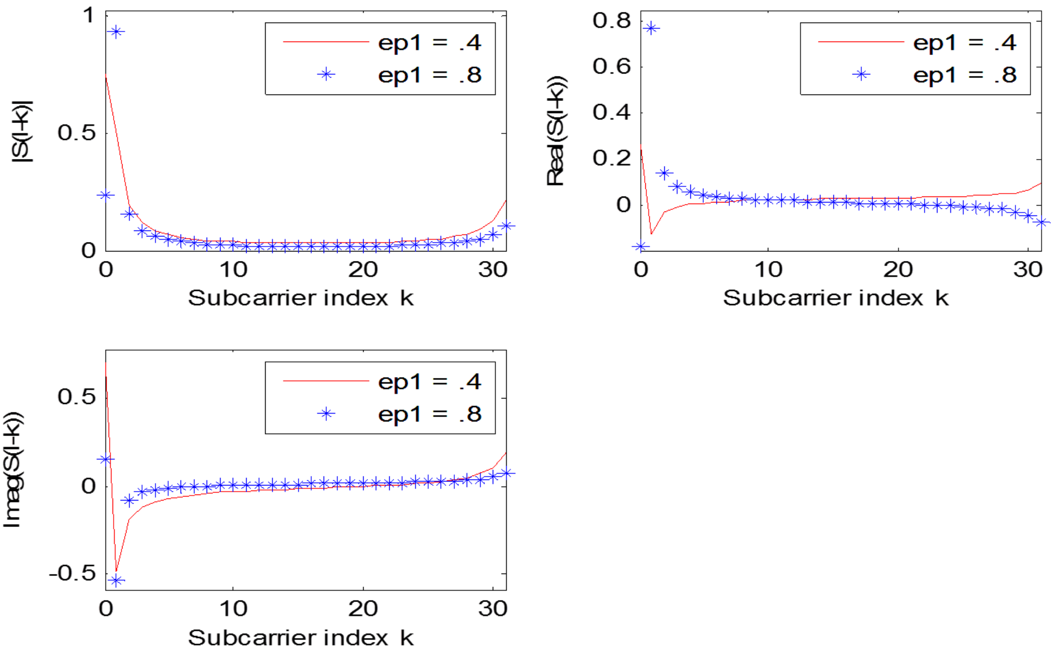

Figure 2: ICI Coefficients for N=32 Carriers

The figure 2 shows that for a larger ε, the weight of the desired signal component, S(0), decreases, while the weights of the ICI components increases. We can notice that the adjacent carrier has the maximum contribution to the ICI. This fact is used in the ICI self-cancellation technique.

IV.ICI SELF CANCELLATION SCHEME

ICI Cancelling Modulation

The main concept of this scheme is to modulate the input data symbol onto a group of subcarriers with predefined coefficients such that the generated ICI signals within that group cancel each other, hence the name self- cancellation. One data symbol is not modulated in to one sub-carrier, rather at least in to two consecutive sub-carriers [8, 9, 10]. ICI Cancelling Modulation: The ICI self-cancellation scheme requires that the transmitted signals be constrained such that $x(1) = -x(0), x(3) = -x(2), \ldots\ldots\ldots. x(N-1) = -x(N-2)$, then the received signal on subcarrier k becomes

$$Y'(K) = \sum_{\substack{l=0 \\ l=even}}^{N-2} x(l)[S(l-K) - S(l+1-K)] + n_k \quad (6)$$

Similarly the received signal on subcarrier k+1 becomes

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$$Y'(K+1) = \sum_{\substack{l=0 \\ l=even}}^{N-2} x(l)[S(l-K-1) - S(l-K)] + n_{k+1} \quad (7)$$

In such a case, the ICI coefficient is denoted as

$$S'(l-K) = S(l-K) - S(l+1-K)$$

It is found that $S'(l-K) \ll S(l-K)$, which is shown in figure 3 (8)

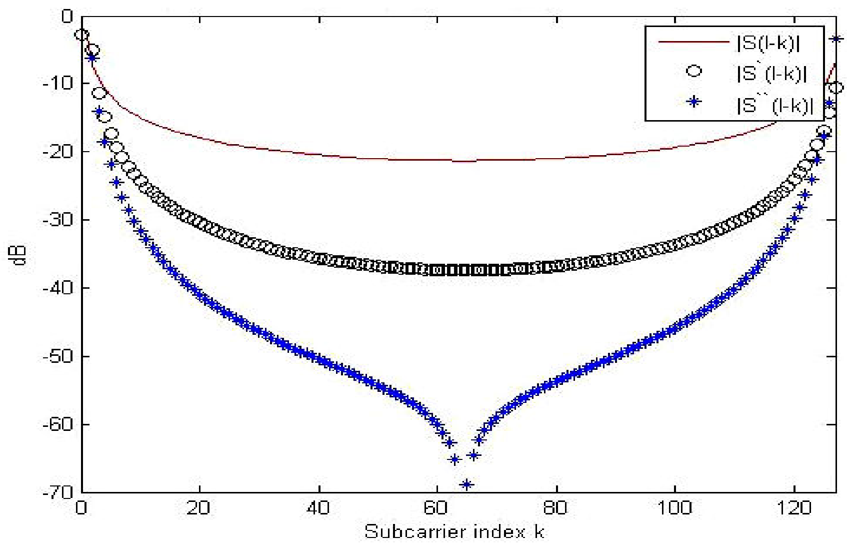

Fig.3Comparison of |S(l-k)|, |S`(l-k)|, and |S``(l-k)| for N = 128 and ε = 0.4

ICI Cancelling Demodulation

ICI modulation introduces redundancy in the received signal since each pair of subcarriers transmit only one data symbol. This redundancy can be exploited to improve the system power performance, while it surely decreases the bandwidth efficiency. To take advantage of this redundancy the received signal at the $(k+1)^{th}$ subcarrier, where k is even, is subtracted from the k^{th} subcarrier. This is expressed mathematically as

$$Y''(K) = Y'(K) - Y'(K+1)$$

$$= \sum_{\substack{l=0 \\ l=even}}^{N-2} x(l)[-S(l-K-1) + 2S(l-K) - S(l-K+1)] + n_k - n_{k+1} \quad (9)$$

Subsequently, the ICI coefficients for this received signal becomes

$$S''(l-K) = -S(l-K-1) + 2S(l-K) - S(l-K+1) \quad (10)$$

Figure3 shows the amplitude comparison of $|S(l-K)|$, $|S'(l-K)|$ and for $|S''(l-K)|$ for N= 64 and ε = 0.3 for the majority of (*l-k*) values, $|S'(l-K)|$ is much smaller than $|S(l-K)|$ and the $|S''(l-K)|$ is even smaller than $|S''(l-K)|$. Thus, the ICI signals become smaller when applying ICI cancelling modulation. On the other hand, the ICI cancelling demodulation can further reduce the residual ICI in the received signals. This combined ICI cancelling modulation and demodulation method is called the ICI self-cancellation scheme On the other hand, the ICI cancelling demodulation can further reduce the residual ICI in the received signals. This combined ICI cancelling modulation and demodulation method is called the ICI self-cancellation scheme

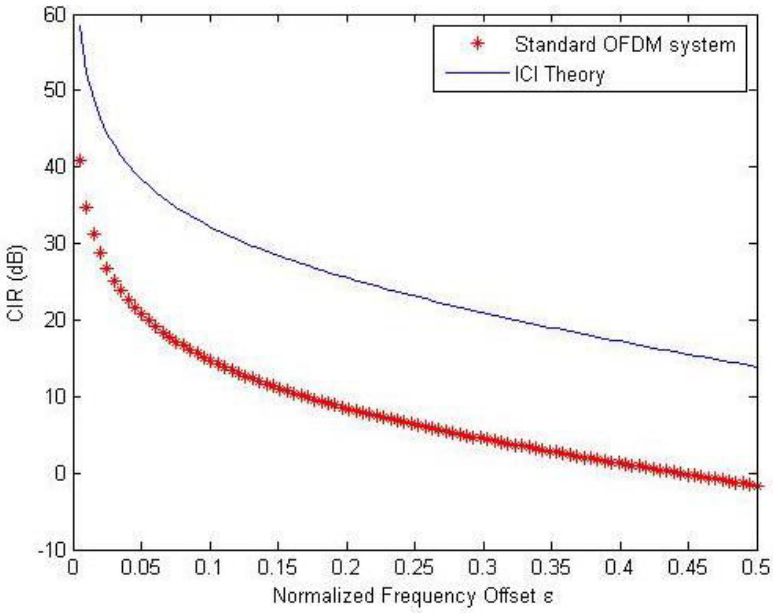

Fig .4 CIR versus ε for a standard OFDM system

V. CONCLUSION

In this paper, the performance of OFDM systems in the presence of frequency offset between the transmitter and the receiver has been analysing in terms of the CIR and the bit error rate (BER) performance. ICI which results from the frequency offset degrades the performance of the OFDM system. Here in this paper we use method of the ICI self-cancellation (SC). The self cancellation does not require very complex hardware or software for implementation. The simulations were performed in an AWGN channel. This model can be easily adapted to a flat-fading channel with perfect channel estimation.

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