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INTER-CARRIER INTERFERENCE REDUCTION IN OFDM SYSTEM

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ABSTRACT

The implementation of OFDM system suffers from the effect of phase noise generated by the local oscillator which disturbs the orthogonality among sub carriers and causes inter carrier interference (ICI). The ICI may also suffers due to insufficient cyclic prefix at the transmitter Self cancellation is the method is suggested for reducing the ICI. The frequency offsets between the transmitter and receiver is measured in terms of carrier to interference ratio (CIR) and bit error rate (BER).

KEYWORDS: Orthogonality, Self Cancellation, Inter Carrier Interference (ICI), Carrier to Interference Ratio (CIR)

INTRODUCTION

OFDM is emerging as the preferred modulation scheme in the modern high data rates wireless communication systems [1, 2.]. OFDM is a special case of MC (Multicarrier modulation). MC is the concept of splitting a signal into a no. of signals, modulating each new signal to several frequency channels and combining the data received on the multiple channels at the receiver. OFDM has been used in many communication systems such as WLAN (wireless LAN), DVB (Digital video broadcasting), etc. However one of the major problems in OFDM is its vulnerability to frequency offset which leads to loss of orhogonality resulting into ICI [3, 4]. For suppressing ICI there is self cancellation, (SC) [5, 6, and 7] techniques in OFDM. Self-cancellation is a two stage technique that uses predefined weighting coefficients to reduce ICI for OFDM systems [8, 9, 10, and 11].

OFDM SYSTEM DESCRIPTION

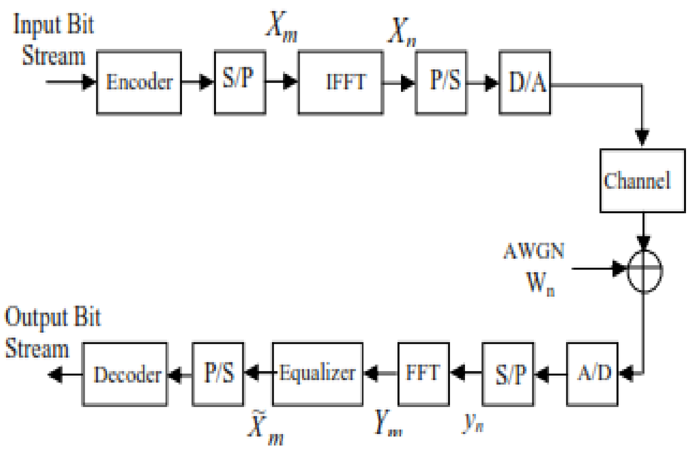

Figure 1: Baseband OFDM Transceiver System

In an OFDM system the input bit stream is multiplexed into N symbol streams each with symbol period T and each symbol is modulate with sub-carriers. A serial to parallel converter groups the stream of input bits from the source encoder into groups of $\log_2 M$ bits. Where M is the alphabet size of digital modulation scheme

A typical discrete-time baseband OFDM transceiver system. A serial to parallel converter groups the stream of input bits from the source encoder into groups of $\log_2 M$ bits. Where M is the alphabet size of the digital modulation scheme employed on each sub-carrier a total of N such symbols X_m are created. The N symbols are mapped to bins of an IFFT. The IFFT bins corresponding to the orthogonal sub-carriers in the OFDM system. Therefore OFDM symbol can be expressed as

$$x(n) = \frac{1}{N}\sum_{m=0}^{N-1} X_m e^{\frac{2\pi nm}{N}} \quad (1)$$

Where X_m is the base band symbol on each sub-carrier

The Digital to Analog converter creates an analog time-Domain signal which is transmitted through the channel. At the receiver, the signal is converted back to a discrete N point sequence y (n), corresponding to each sub-carrier. The discrete signal is demodulated using an N-point FFT operation at the receiver

The demodulated symbol stream is given by

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

Where w (m) corresponds to the FFT of the samples of w (n), which is the additive white Gaussian noise (AWGN) introduced in the channel. The high speed data rates for OFDM are accomplished by the simultaneous transmission of data at a lower rate on each of the orthogonal sub-carriers. Because of low data rate transmission distortion in the received signal induced by multipath delay in the channel is not as significant as compared to single carrier high data rate systems.

Multipath distortion can also cause inter symbol interference (ISI) where adjacent symbols overlap with each other. The ISI is prevented in OFDM by the insertion of a cyclic prefix between successive OFDM symbols. This cyclic prefix is discarded at the receiver to cancel out ISI.

ANALYSIS OF INTER-CARRIER INTERFERENCE

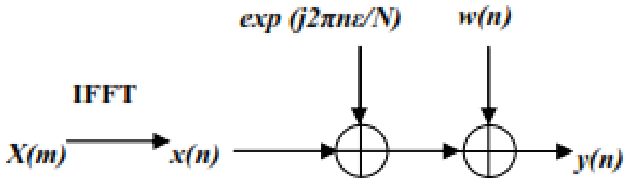

Figure 2: Frequency Offset Model

The main disadvantage of OFDM is its susceptibility to small differences in frequency at the transmitter and receiver, normally referred to as frequency offset. This frequency offset can be caused by Doppler shift due to relative motion between the transmitter and receiver or by difference between the frequencies of the local oscillators at the transmitter and receiver.

The frequency offset is modeled as a multiplicative factor introduced in the channel

The received signal is given by

$$y(n) = x(n) e^{j\frac{2\pi n\varepsilon}{N}} + w(n) \quad (3)$$

Where $\in$ is the normalized frequency offset and is given by ΔfNT_s. Where Δf the frequency difference between the transmitted and received carrier frequencies is T_s is the subcarrier symbol period (n) is the AWGN introduced in the channel.

The effect of this frequency offset on the received symbol is given by Y (k) on the kth subcarrier

$$Y(k) = X(k)S(0) + \sum_{l=0, l\neq k}^{N-1} X(l)S(l-k) + nk \tag{4}$$

Where N is the total number of subcarriers, X(k) is the transmitted symbol for the kth subcarrier, n^{k} is the FFT of w(n), and S(l-k) are the complex coefficients for the ICI components in the received signal. The ICI components are the interfering signals transmitted on sub-carriers other than the kth sub-carrier. The complex coefficients are given by

$$S(l-k) = \frac{\sin\left(\pi(l+\in -k)\right)}{N\sin(\pi(l+\in -k))} \exp\left(j\pi\left(1-\frac{1}{N}\right)(l+\in -k)\right) \tag{5}$$

To analyze the effect of ICI on the received signal. We consider a system with N=16 carriers. The frequency offset values used are 0.2 and 0.4 and l is taken as 0. That is, we are analyzing the signal received at the sub-carriers with index 0. The complex ICI Coefficient S (l-k) are plotted for all sub-carrier indices

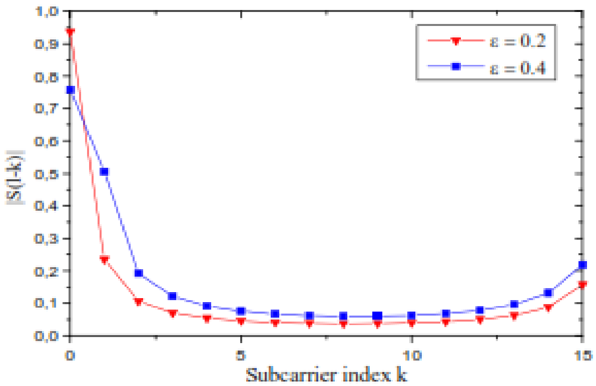

Figure 3: ICI Coefficients for N=16 Carriers

ICI SELF-CANCELLATION SCHEME

The main idea is to modulate the input data symbol on to a group of sub-carriers with predefined coefficients such that the generated ICI signals within that group cancel each other hence the name self-cancellation.

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),…..,X(N-1) = -X(N-2).

Using equation….(5) the transmitted symbols allows the received signal on sub-carriers k and k+1 to be written as

$$Y(k) = \sum_{l=0\ l=even}^{N-2} X(l)[S(l-k) - S(l+1-k)] + n_k \tag{6}$$

$$Y(k+1) = \sum_{l=0\ l=even}^{N-2} X(l)[S(l-k-1) - S(l-k)] + n_{k+1} \tag{7}$$

And the ICI coefficient **S' (l-k) = S(l-k)-S(l+1-k)**

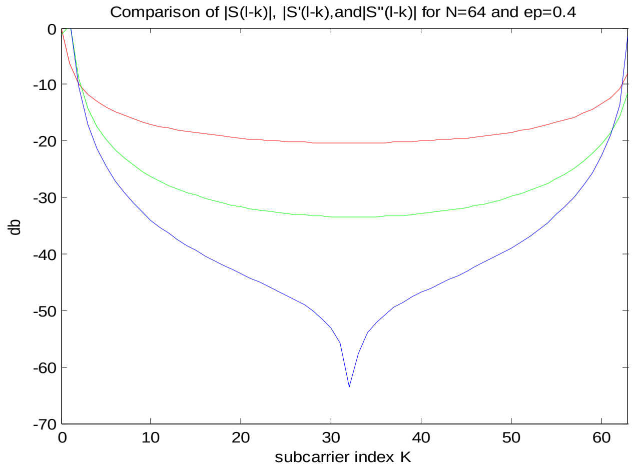

Figure 4: Comparison of |S (l-k)|, |S' (l-k)|, and |S" (L-k)| for N=64 and ep=0.4

Figure 4. shows a comparison between |S' (l-k)| and |S (l-k)| on a logarithmic scale. It is seen that |S' (l-k)|<<|S (l-k)| for most of the l-k values.

ICI Cancelling Demodulation

ICI modulation introduces redundancy in the received signal each pair of sub-carriers transmit only one data symbol. The received signal at the (k+1) Th sub-carrier. Where k is even, is subtracted from the k th sub-carrier. This is expressed mathematically as

Y"(k)=Y'(k)-Y'(k+1)

$$= \sum_{l=0\, l=even}^{N-2} X(l)[-S(l-k-1)+2S(l-k)-S(l-k+1)]n_k - n_{k+1} \quad (8)$$

The ICI coefficients for this received signal becomes

$$s''(l-k) = -S(l-k-1)+2S(l-k)-S(l-k+1) \quad (9)$$

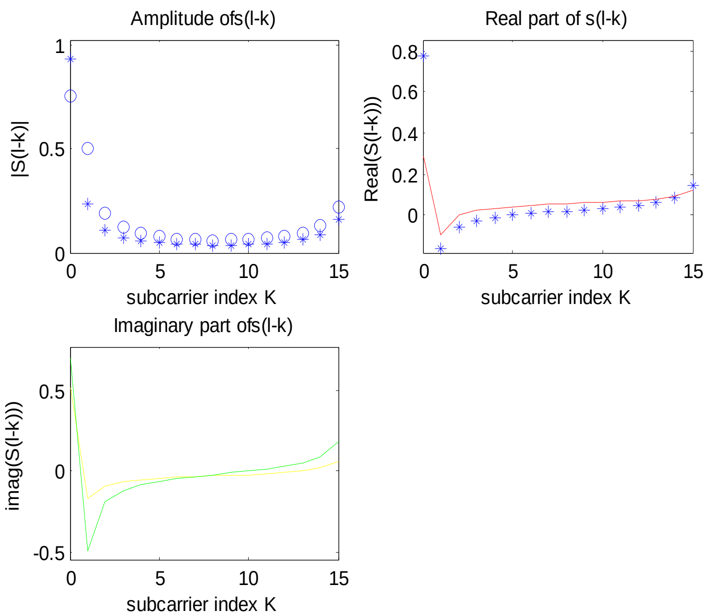

Figure 5: An Example of S(l-k) for N=16; l=0. (a) Amplitude of S (l-k). (b) Real Part of S(l-k). (c) Imaginary Part of S(l-k)

When compared to the two previous ICI coefficients |S(l-k)| for the standard OFDM system and |S'(l-k)| for the ICI cancelling modulation. |S''(l-k)| has the smallest ICI coefficients for the majority of l-k values, followed by |S'(l-k)| and |S (l-k)|.

The reduction of the ICI signal levels in the ICI self-cancellation scheme leads to a higher CIR. The theoretical can be written as

$$CIR = \frac{|-S(-1)+2S(0)-S(1)|^2}{\sum_{l=2,4,6}^{N-1}|-S(l-1)+2S(l)-S(l+1)|^2} \quad (10)$$

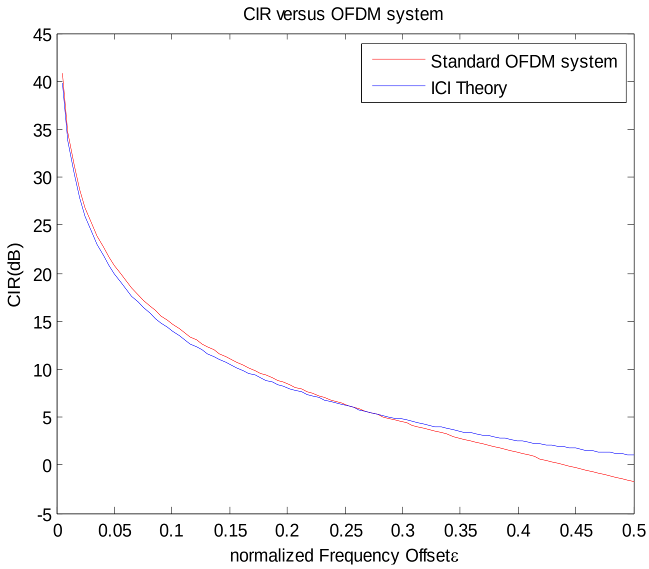

Figure 6: CIR vs. for a Standard OFDM System

SIMULATION

In order to evaluate the performance of OFDM systems in the presence of frequency offset between the transmitter and the receiver. BER curves were used. For the simulations in this paper, MATLAB. Modulation scheme of 2- psk and QAM were chosen Simulations for cases of normalized frequency offsets equal to 0, 0.05, 0.15 and 0.3.

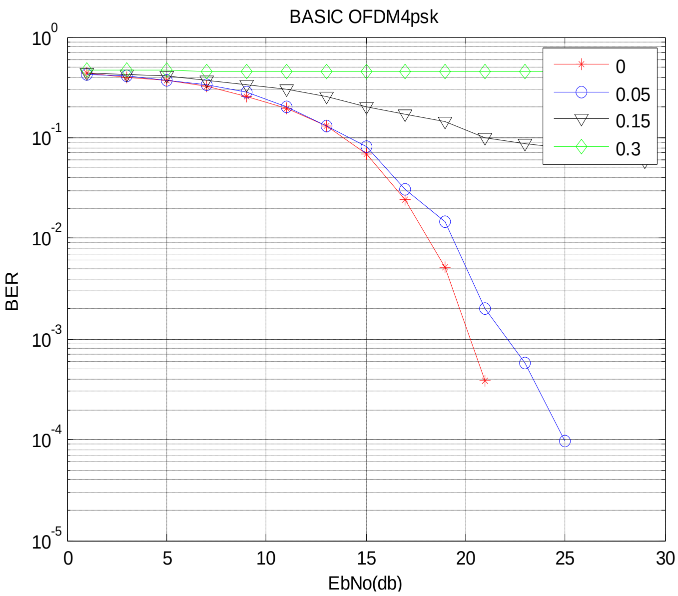

Figure 7: BER vs E_b No for Basic OFDM Using 4-PSK for Different Values of Epsilon

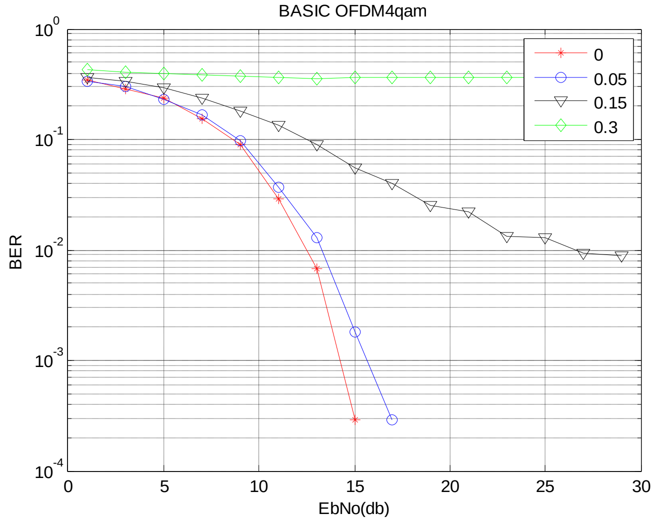

Figure 8: BER vs. E_bNo for Basic OFDM Using QAM for Different Values of Epsilon

These results shows that degradation of performance increases with frequency offset. When frequency is small, the 2-psk and 2-QAM system has a lower BER.

Comparisons of the performance of the SC schemes for different values of the frequency offset ep=0 &0.15.

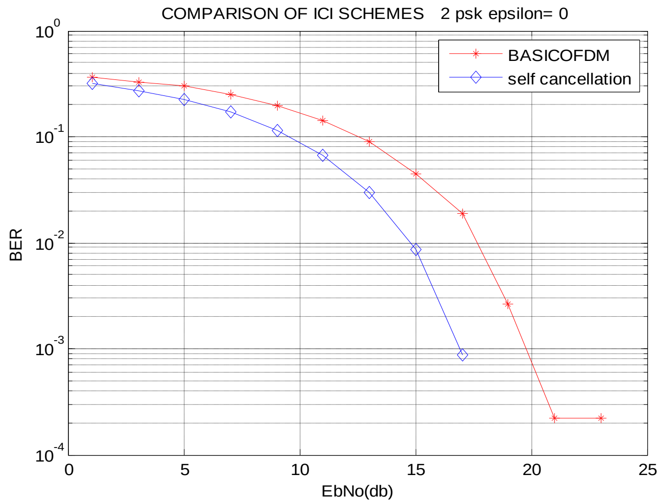

Figure 9: Comparison of Basic OFDM and Self Cancellation Method for Epsilon=0

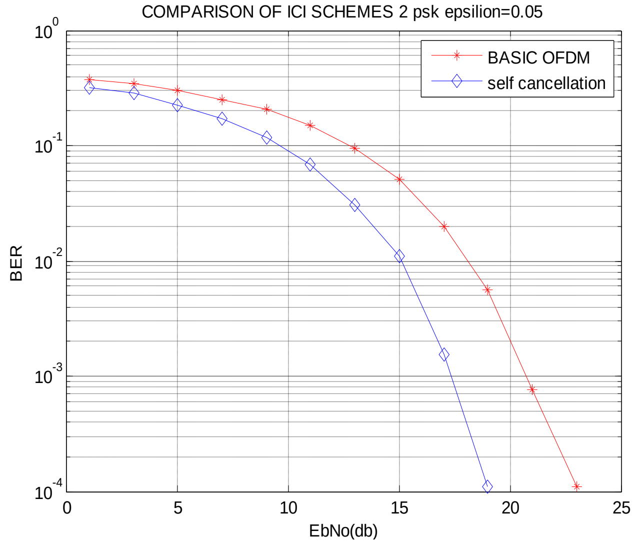

Figure 10: Compare of Basic OFDM and Self Cancellation Method for Epsilon=0.05

CONCLUSIONS

In this paper, the performance of OFDM system in the presence of frequency offset between the transmitter and receiver has been studied in terms of carrier-to-interference ratio (CIR). The bit error rate (BER). Inter-carrier interference (ICI). Which results from frequency degrades the performance of the OFDM system. Self cancellation does not require very complex hardware or software for implementation. However, it is not band width efficient as there is a redundancy of 2 for each carrier.

All simulations were performed in an AWGN Channel.

REFERENCES

1. K. Witrisal, Y. H Kim, R. Prasad, and al.ap. Light art, “Experimental Study and Comparison of OFDM Transmission Techniques,” 5th international OFDM-Workshop in Hamburg, September 2000.
2. Eric Lawrey and Comelis Jan Kikkert, “Maximing Signal Strength for OFDM Inside Buildings,” IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES, VOL.49, NO.11, NOVEMBER 2001.
3. Luca Ruguni and Paolo Banelli, “BER of OFDM systems Impaired by Carrier Frequency Offset in Multipath Fading channels,” IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS, VOL.4, NO.5, SEPTEMBER 2005.
4. Jean Armstrong, “Analysis of New and Existing Methods of Reducing Intercarrier Interference Due to Carrier Frequency Offset in OFDM,” IEEE TRANSACTIONS ON COMMUNICATIONS, VOL.47, NO.3, MARCH 1999.
5. Yen-hui Yeh and Sau-Gee Chen, FAST_FADING CHANNEL ESTIMATION AND EQUALIZATION METHOD WITH SELF ICI CANCELLATION, national Science Council, Taiwan.
6. K. Sathananthan and C. Tellambura, “partial Transmit sequence and selected Mapping Schemes to Reduce ICI in OFDM system,” IEEE COMMUNICATIONS LETTERS, VOL.6, NO 8 AUGUST 2002.
7. Xiaodong Cai and Georgios B.Giannakis,”Low-complexity ICI suppression for OFDM over Time and Frequency-Selective Rayleigh Fading Channels,” Dept of ECE, University of Minnesota, 2002 IEEE.
8. R. Zhang, T. T. Tjhung H.J.Hu and P. He, “Window Function and Interpolation Algorithm for OFDM Frequency-Offset Correction.”
9. Assmin Mostofi and Donald C. Cox, “ICI Mitigation for Pilot-aided OFDM Mobile Systems”, IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS, VOL .4, NO.2, MARCH 2005.
10. Over Edfors, Magnus Sand ell, Jan- Jaap van de Beek, Daniel Landstrom and Frank Sjoberg, “AN INTRODUCTION TO ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING,” September 1996.
11. Yupingzhao and Sven-Gustav Haggman, “Intercarrier Interference Self Cancellation Scheme for OFDM Mobile Communication Systems,” IEEE Trans. Communication, vol. COM -49, pp. 529-540, July 2001.