DESIGN AND IMPLEMENTATION INTER CARRIER INTERFERENCE REDUCTION USING SELF CANCELLATION IN OFDM

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Abstract: *MIMO OFDM is a multicarrier modulation techniques in which a high rate bit stream is split into N parallel bit- stream of inferior rate and each of these are modulated using one of N orthogonal sub-carriers. OFDM is robust to multi- paths evaporation and delay because it has high data transmission capability with high bandwidth efficiency that's why it has recently been functional in wireless communication systems. It is highly sensitive to frequency offset introduced by the wireless channels and causes loss of orthogonality and amplitude reduction of OFDM signal and lead to Inter Carrier Interference (ICI). There are two deleterious effects caused by frequency offset one is the reduction of signal amplitude in the output of the filters matched to each of the carriers and the second is introduction of ICI from the other carriers a main problem in MIMO OFDM is its susceptibility to frequency offset errors due to which the orthogonality is destroyed that result in that Inter carrier Interference (ICI). ICI causes power leakage among subcarriers thus degrading the system act. Here in this paper, ICI cancellation structure in MIMO-OFDM which performs better than standard OFDM system. Later we proposed Self cancellation method in MIMO OFDM to enhance the performance of the system by reducing the BER for different values of signals to noise fraction (SNR).*

Key words: *OFDM, MIMO OFDM Model, inter carrier interference self-cancellation (ICI SC)*

INTRODUCTION

Orthogonal frequency division multiplexing (OFDM) has become a popular technique for transmission of signals over wireless networks. OFDM has been approved in several wireless standards such as digital audio broadcasting (DAB), digital video broadcasting (DVB-T), the IEEE 802.11a local area network (LAN) standard and the IEEE 802.16a [10] metropolitan area network (MAN) standard. OFDM is also being tracked for dedicated short-range communications (DSRC) for road side to vehicle communications and as a potential candidate for fourth- generation (4G) mobile wireless systems. OFDM systems though quite effective in avoiding inter-symbol interference (ISI) due to multipath delay

[11], suffers from the front-end distortions such as carrier frequency offset (CFO) which destroys the orthogonality among subcarriers in one OFDM symbol and thus causing inter-carrier interference (ICI) [11]. These frequency differences are often caused by the Doppler shift and/or mismatch between oscillators in the transmitter and receiver [11]. This ICI due to frequency offset can be reduced by decreasing the sensitivity of the OFDM systems towards the frequency offset errors.

A number of techniques have been developed for reducing ICI in OFDM systems. These techniques include the frequency domain equalization [12], the time domain windowing [13] and the ICI self-cancellation schemes [14], [15] and [16]. Among these, much attention has been paid to the ICI self cancellation scheme because of its implementation simplicity. Its main idea is to map one data symbol onto a group of subcarriers with predefined weighting quantities. From this, the ICI signals created within a group could be ―self-cancelled. The importance of the present learning is to investigate some techniques to eliminate the effect of carrier frequency offset (CFO) on MIMO-OFDM systems for cancellation of ICI. To eliminate the effect of CFO on MIMO-OFDM systems, ICI self-cancellation scheme are applied here for MIMO-OFDM systems and then compared to the ICI self cancellation scheme for OFDM system.

OFDM BASIC BUILDING BLOCK

MIMO OFDM is emerging as the preferred modulation scheme in modern high data rate wireless communication methods. OFDM has been accepted in the European digital audio and video broadcast radio system and is being investigated for broadband indoor wireless communications. Standards such as HIPERLAN2 (High Performance Local Area Network) and IEEE 802.11a and IEEE 802.11b have emerged to support IP-based facilities. Such schemes are established on OFDM and are aimed to work on 5 GHz band. OFDM is a superior case of multi-carrier modulation. Multi-carrier is the theory of splitting a signal into a numeral signals, modulating individual new signals to a number of frequency channels, and connecting the data received on the various channels at the receiver. In OFDM, the several frequency channels, identified as sub-carriers, are orthogonal to each other. One of the principal advantages of OFDM is its utility for transmission at very nearly optimum performance in unequalized channels and in multipath channels.

In this paper, the effects of ICI have been analyzed and a solution to combat ICI has been presented. Self- cancellation scheme [1], in which redundant data is transmitted onto adjacent sub-carriers such that the ICI between adjacent sub-carriers cancels out at the receiver. The average carrier to power interference ratio CIR is used as the ICI level indicator and the theoretical CIR expression is derived for the proposed scheme.

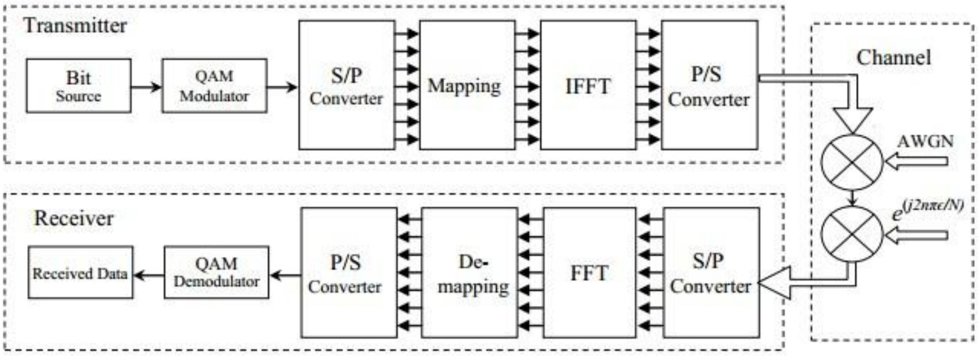

Fig . 1.1 Block Diagram of an OFDM System

The Fig. 1 describes a simple idealized OFDM system model suitable for a time-invariant AWGN channel. In an OFDM system, the complex baseband OFDM signal after the IFFT block at the transmitter can be expressed as

$$x(n)=\frac{1}{N}\sum_{k=0}^{N-1} X(k)e^{j\frac{2\pi nk}{N}}, \qquad n=0,1,2...N-1 \tag{1}$$

where N is the total number of subcarriers, X(k) denotes the transmitted quadrature amplitude modulation (QAM) or M- ary phase-shift keying (PSK) modulated symbol on the subcarrier k with k = 0, 1, 2, …, N −1. The received signal after being affected by the frequency offset can be written as

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

Where,€ signifies as the frequency offset standardized by the subcarrier separation and is given by ΔfNT_S with Δf being the frequency difference between the transmitted and received carrier frequency, T_S is the symbol period, and w(n) which is invariant AWGN introduced in the channel.

$$Y(k) = \sum_{n=0}^{N-1} y(n)e^{\frac{-j2\pi nk}{N}}, \qquad k = 0,1,\dots,N-1 \tag{3}$$

At the receiver, after the FFT block, the received signal on the subcarrier k suffering from the frequency offset can be written as

Carrier to interference ratio (CIR) can be defined as a ratio between the desired power and undesirable power. It rises when standardized frequency shift (ε) decreases and vice versa. It is used to determine the performance of the whole method. The objective of all ICI reduction systems is to get a larger value of CIR.

The hypothetical CIR for normal OFDM can be given as

$$\mathrm{CIR} = \mathrm{abs}(S(0)) \div \sum_{\substack{l=0 \\ l \neq k}}^{N-1} \mathrm{abs}\,(S(l-k)) \tag{4}$$

This above can be efficient for all kinds of variations and for any number of subcarriers; but the derivation assumes that: the standard transmitted data has zero mean, the symbols transmitted on the different subcarriers are statistically independent, and the additive noise is omitted.

MIMO OFDM SYSTEM

MIMO wireless technology is a potential scheme that seems to fulfill these demands by offer increased spectral efficiency through spatial-multiplexing and upgraded link consistency due to antenna diversity [2], [3- 4].

The MIMO antennas when combined with OFDM can further improve system performance and is considered as an attractive solution for next generation systems. Similar to SISO-OFDM systems, the major problem in MIMO- OFDM systems are their sensitivity to phase noise and carrier frequency offset (CFO), which induces ICI [5].

The objective of this study is to investigate some techniques to eliminate the effect of CFO on MIMO-OFDM systems for cancellation of ICI. To eliminate the effect of CFO on MIMO-OFDM systems, the previously mentioned ICI cancellation schemes (e.g. ICI self-cancellation [6], PCSC [7] scheme) are extended here for MIMO-OFDM schemes and a novel scheme to cancel ICI by equalization of the weighting coefficients is proposed for MIMO-OFDM systems

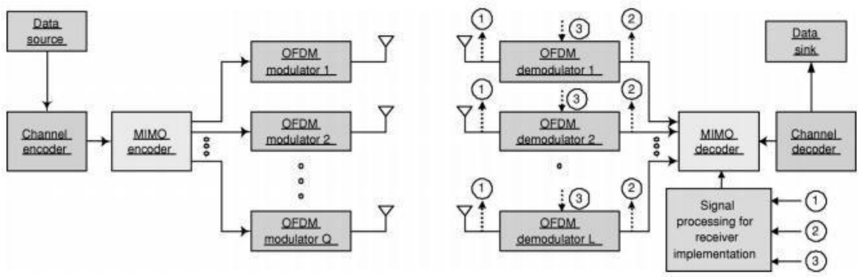

Fig 1.2 MIMO OFDM Implementation

A multicarrier system can be efficiently implemented in discrete time using an inverse FFT to act as a modulator and an fft to act as a demodulator. The transmitted data are the frequency domain coefficient and the samples at the output of the IFFT stage are —time domain samples of the transmitted waveform. Fig 2 show a MIMO OFDM implementation.

Broadband MIMO Fading Channel

The main motivation for using OFDM in a MIMO channel is the fact that OFDM modulation turns a frequency- selective MIMO channel into a set of parallel frequency- at MIMO networks. This reduces multi-channel equalization mostly simple, since to each OFDM-tone, only a continuous matrix has to be inverted [8].

In a MIMO-OFDM system with N subcarriers (or tones) the individual data streams are first passed through OFDM modulators which perform an IFFT on blocks of length N followed by a parallel-to-serial conversion.

ICI SELF-CANCELLATION SCHEME

ICI self-cancellation is a method that was first presented by Yuping Zhao and Sven-Gustav Häggman in to combat and suppress ICI in OFDM.

The main drawback of OFDM and MIMO-OFDM, however, is its receptiveness to small differences in frequency at the transmitter and receiver, usually denoted as frequency offset. This frequency offset is due to Doppler shift causes relative motion between the transmitter and receiver, or by the variations between the frequencies of the local oscillators at the transmitter and receiver. It is seen that the difference between the ICI co-efficient of two successive sub-carriers are very small. The main idea is to modulate the input data symbol onto a group of subcarriers with predefined coefficients such that the generated ICI signals within that group extract each other, hence named as self-cancellation.

Self cancellation in OFDM System

In an OFDM communication system, self cancellation of OFDM model is as shown in Fig 1.3. For example, if symbol X is transmit, then it will be drawn into two nearby sub-carriers with (X, -X) values, assuming the channel frequency offset normalized by the subcarrier distance is ε, and then the signal received on subcarrier k can be given as:

$$Y_k' = \sum_{l=0,2,4,\cdots}^{N-2} X(l)[S(l-k) - S(l+1-k)] + n_k \quad (5)$$

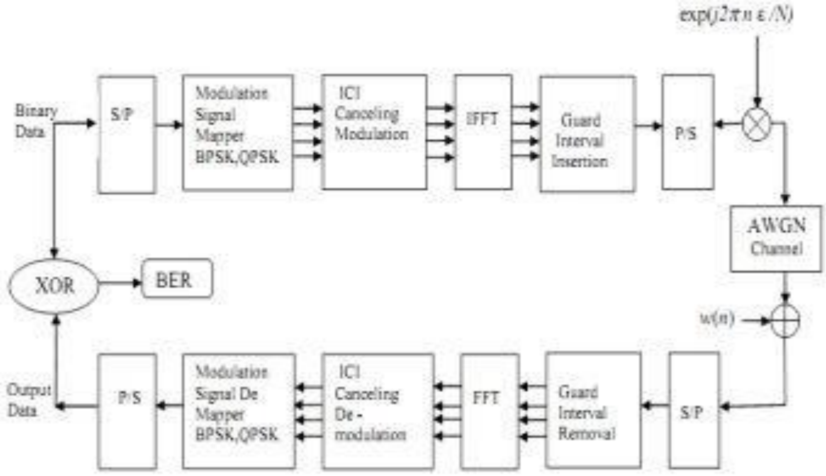

Fig: 1.3 OFDM model with self cancellation

Where nk denotes the additive noise symbol introduced in sub-carrier k , and Y'k denotes the received symbol in sub- carrier k

The received symbol in sub-carrier k+1 is represented by:

$$Y'_{k+1} = \sum_{l=0,2,4,\cdots}^{N-2} X(L)[S(l-k-1) - S(L-k)] + n_{k+1} \quad (6)$$

And the ICI coefficient S'(l-k) is referred to as :

$$S'(l-k) = S(l-k) - S(l+1-k) \quad (7)$$

which is better than the actual one. Improved coefficient can be attained by deducting the two adjacent carriers, the output will be :

$$Y''(k) = Y'(k) - Y'(k+1) = \sum_{l=0,2,4,\cdots}^{N-2} X(l)[-S(l-k-1) + 2S(l-k) - S(l-k+1) + n_k - n_{k+1}] \quad (8)$$

The derivation accepts that the typical transmitted data has zero mean; the symbols transmitted on the different sub-carriers are statistically not dependent on each other, and the additive white noise is omitted.

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. Hence, the ICI components are much smaller in (7). Also, the total number of interference

signals is halved in (9) since only the even subcarriers are involved in the summation. Comparison of |S(1-k)|,|S''(1-k)|, and |S'''(1-k)| for ε=0.3 and N=64.

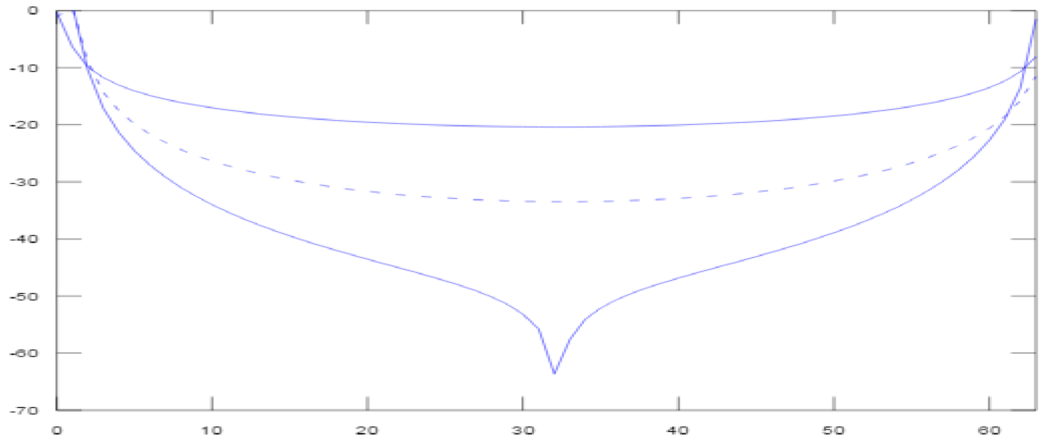

Fig. 1.4 : ICI coefficients for ∈

Frame Timing Offset

The estimation of the MIMO OFDM symbol or frame start position determines the alignment of the FFT window with the non-cyclically extended MIMO OFDM symbol. An offset in the FFT window can then include a neighboring MIMO OFDM symbol causing ISI, which can affect the orthogonality of the sub-carriers producing ICI. Analysis of the effects of frame timing offset on the constellation and the spectrum will be discussed with and without the use of a cyclic prefix for QPSK. We proceed first with the latter case.

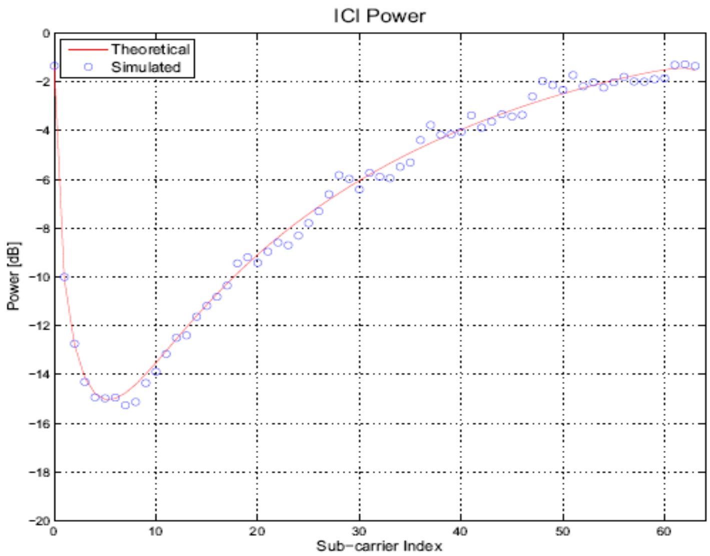

Fig : 1.5 ICI Power

CONCLUSION

In this paper, the self-cancellation in MIMO-OFDM systems has been proposed over multipath fading channel. The proposed system can be used in the realistic fading channels. As compared to the OFDM systems, the proposed system offers better CIR than the ordinary one. Simulation results show that the proposed system achieves lower BER in AWGN channels as compared to the ordinary OFDM systems. In this section, the proposed self-cancellation scheme in OFDM systems is examined the performance through a computer simulation. Total power of the system is 1 Watt. The transmitted power of this scheme is a half of the ordinary OFDM systems. Moreover in this method all the signal processing is dependent on one independent process i.e. estimation of the FFT window and hence the question of dependency of two independent process does not arise at all. The method is more promising for large delay spread channels and provides a significant Eb/N0 improvement in the detection process

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