Performance of BER Using IA Based Precoding in SISO-OFDM System

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Abstract: ***In this paper we propose performance of BER in SISO-OFDM system using IA based precoding technique. By using precoding technique we have to remove inter-block interference and intercarrier interference from SISO-OFDM ststem. These paper also explains block diagram of SISO-OFDM system in detail and it consist one receive antenna and one transmit antenna. This paper shows BER analysis using IA based precoding for different block based transmission such as SC-FDE,CP-OFDM,ZP-only in SISO-OFDM Systems. This paper also highlights bit erro rate and bit error probability.***

Keywords: SISO-OFDM, Precoding, BER, Cyclic prefix,IBI

1. Introduction

The next generation wireless communication systems have multimedia and Wireless broadband internet services. The Orthogonal Frequency Division Multiplexing (OFDM) and Multiple Input Multiple Output (MIMO) technology are essential parts of advanced wireless communications systems because these technologies has high data rate, efficient spectrum utilization and reliable error-free communication. OFDM is multicarrier transmission technique which divides available frequency band in multiple subcarriers and each subcarrier modulated by low data rate stream. It has high spectral efficiency and remove effects of ISI. MIMO allows high data rate transmission through multiple antennas on both communication ends (transmitter & receiver) which not only increases channel capacity, but also allows multiple diversity schemes to be exploited in order to further enhance the overall system capacity [1] [2].

In a SISO-OFDM system with insufficient CP, if the IBI from the previous OFDM block can be separated and eliminated, it will be easier to detect the current OFDM block from the desired signal term and the ICI term both of which contain the information of the current OFDM symbol. The basic idea of IA is to use well-designed “beam forming” vectors at the transmitter such that the interference vectors are aligned at the receiver in one subspace which is disjoint from the signal subspace. As a result, the interference vectors are separated from the desired signal subspace and are limited in the minimum dimensions and therefore can be eliminated by the zero-forcing operator at the receiver. This basically provides an interference nulling technique [1] [5] [6] [7].

The MIMO system consist four model such as SISO model, MISO model, SIMO model and MIMO model. In this paper, we discuss about only SISO model. SISO-OFDM system consist one transmit antenna and one receive antenna. There are three type of block based transmission system such as CP-OFDM, SC-FDE and zero padding used in SISO-OFDM system. Using these three block based transmission system with IA based precoding we have to remove inter-block interference in SISO case.

2. System Design

The following block diagram is of SISO-OFDM system which consists single transmit antenna and single receive antenna. In this diagram, the binary source generates digital input data sequence. This binary data is encoded by using digital modulation scheme like BPSK, QPSK and QAM with several different single constellations. The serial to parallel block performs data symbols parallelized in N different substreams. Each substream will modulate a separate carrier through the IFFT modulation block. The IFFT block converts parallel sub-streams of frequency domain data symbols into a time domain OFDM symbol. After that we have to insert cyclic prefix to remove inter-block interference and inter-symbol interference. The cyclic prefix means we have to copied last specific length of data bits in start of OFDM symbol. The data are back convert into parallel to serial form. This serially converted data is transmitting from single transmit antenna to single receive antenna through the channel and AWGN noise is added in received OFDM symbol through the channel.

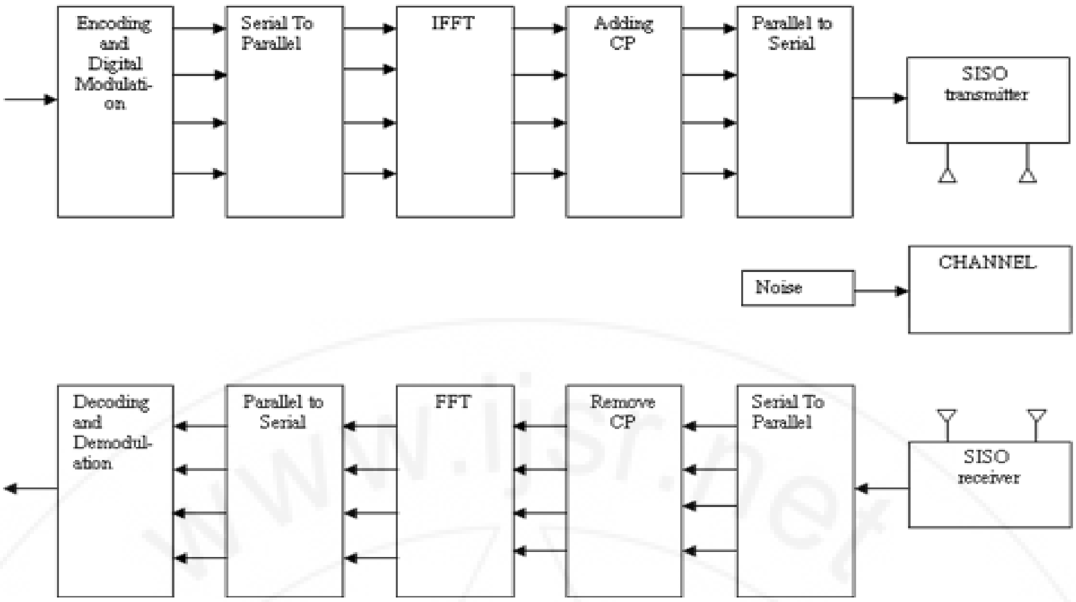

Figure1: Block diagram SISO-OFDM System

The received data are first converted in serial to parallel form and also remove cyclic prefix. The FFT block convert this data from time domain symbol in frequency domain and again covert it parallel to serial form. When we have to demodulate and decode the data, we get estimated output. The SISO-OFDM system has single input and single output.

3. Performance Analysis of the System

3.1 Bit Error Rate Analysis

When data is transmitted over a data link, there is a possibility of errors being introduced into the system. If errors are introduced into the data, then the integrity of the system may be compromised. As a result, it is necessary to assess the performance of the system, and bit error rate, BER, provides an ideal way in which this can be achieved.

Unlike many other forms of assessment, bit error rate, BER assesses the full end to end performance of a system including the transmitter, receiver and the medium between the two. In this way, bit error rate, BER enables the actual performance of a system in operation to be tested, rather than testing the component parts and hoping that they will operate satisfactorily when in place. Bit error rate(BER) is defined as the rate at which errors occur in a transmission system. This can be directly converted into the number of errors that occur in a string of a stated number of bits. The definition of bit error rate can be translated into a simple formula:

BER = number of errors / total number of bits sent

If the medium between the transmitter and receiver is good and the signal to noise ratio is high, then the bit error rate will be very small - possibly insignificant and having no noticeable effect on the overall system However if noise can be detected, then there is chance that the bit error rate will need to be considered.

The main reasons for the degradation of a data channel and the corresponding bit error rate, BER is noise and changes to the propagation path (where radio signal paths are used). Both effects have a random element to them, the noise following a Gaussian probability function while the propagation model follows a Rayleigh model. This means that analysis of the channel characteristics are normally undertaken using statistical analysis techniques.Another contributory factor for bit errors is any phase jitter that may be present in the system as this can alter the sampling of the data

3.2. Bit Error Probability

In this section, we analyze the error performance of the STBC system, in which $2m$ bits are transmitted during two consecutive symbol intervals using one of the $cM2 = 22m$ different STBC transmission matrices, denoted by **X**1,**X**2, . . . ,**X**22m here for convenience. An upper bound on the average bit error probability (BEP) is given by the well known union bound:

$$P_b \leq \frac{1}{2^{2m}} \sum_{i=1}^{2^{2m}} \sum_{j=1}^{2^{2m}} \frac{P(X_i - X_j) n_{i,j}}{2m} \quad (1)$$

3.3 BER Analysis Using IA Based Precoding for Different Block Based Transmission in SISO Systems

We now discuss the relationships of our above IA based channel independent precoding technique with block based transmission systems such as zero-padded (ZP) only, CP-OFDM and single carrier frequency domain equalizer (SCFDE).For convenience we consider only the SISO configuration, i.e., $nt = nr = 1$, without loss of generality it discuss in below.

We consider first the ZP-only transmission system [12] [13] [14]. In this system, The block length of information symbol is M and length of ZP is L in order to eliminate the IBI completely. The ZP idea appears in [9], [10] where a precoder in the time domain is

$$\begin{bmatrix} \mathbf{I}_K \\ \mathbf{0}_{(N-K)\times K} \end{bmatrix}, \qquad (2)$$

Which becomes the ZP-only scheme when $K = M$ and $N - K = L$. Comparing to the IA based precoding scheme proposed in [1] to completely eliminate the IBI, we take $N = M+L$ when $K = M$, $n_t = 1$, and $v = 0$, no CP is used in this case. The precoding matrix $\mathbf{P}$ is designed as the $N \times K$ sub matrix of the $N \times N$ DFT matrix, i.e., the $(m, n)th$ entry of this precoding is expressed as

$$[\mathbf{P}]_{m,n} = (1/\sqrt{N})\exp(-j2\pi mn/N) \quad (3)$$

As a result, we have $\mathbf{Q}_{zp} = \mathbf{W}_N\mathbf{P} = [\mathbf{I}_K, \mathbf{0}_{K\times L}]^T$ that is the same as the precoder (2) proposed in [9], [10].

Next we consider the CP-OFDM system means the conventional OFDM system. In this system the block length of information symbol is M(IDFT size) and CP length is L in order to eliminate the IBI completely. Comparing to the IA based precoding scheme proposed in [1] to completely eliminate the IBI, we take $N = K = M$ and $v = L$, i.e., full CP length is used in this case. The precoding matrix is the identity matrix, i.e., $\mathbf{P} = \mathbf{I}N$ [1].

Finally we consider the SC-FDE system, with the block length of information symbol is M and CP length is L in order to eliminate the IBI completely. Comparing to the IA based precoding scheme proposed in [1] to completely eliminate the IBI, we take $N = K = M$ and $v = L$, i.e., full CP length is used in this case. The precoding matrix $\mathbf{P}$ is chosen as the $N \times N$ DFT matrix, i.e., $\mathbf{P} = \mathbf{W}HN$ and the precoding cancels the IDFT operation means the transmission matrix $\mathbf{Q}$ is the identity matrix, thus it leads to transmit the information symbols directly. Note that when the CP length $v = L$, i.e., full (or sufficient) CP is used [8] [14] [16].

From the above discussions, we can see that the three existing block based transmission systems, ZP-only, CP-OFDM, and SC-FDE systems. It can be all considered as special cases of our proposed IA based channel independent precoding scheme in this paper.The IA concept may choose better channel independent precoding matrices $\mathbf{P}$ (or $\mathbf{Q}$) such that less number of CP or ZP are needed to completely eliminate the IBI caused from the ISI of the channel, when the number of information symbols is fixed.

4. Simulations Results

The following figure shows scatter plot constellation size at transmitter means it is input of SISO-OFDM system when $nt = nr = 1$.The constellation size M = 16.

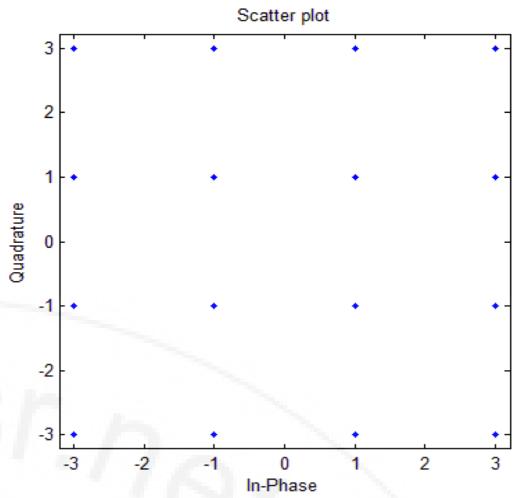

Figure 2: Constellation size at transmitter

The below figure shows constellation size at receiver side means output of SISO-OFDM system and it shows also the number of input is equal to number of output.

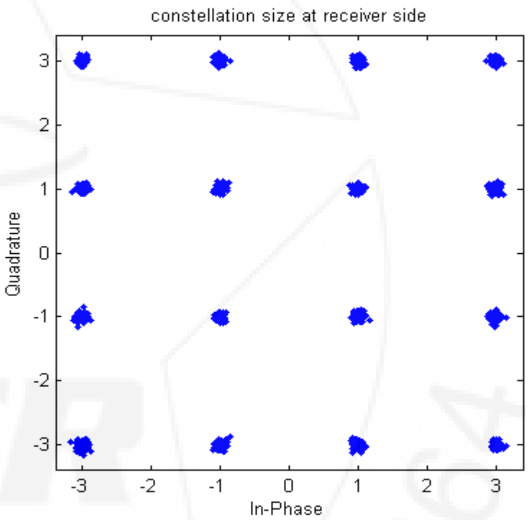

Figure 3: Constellation size at receiver

The following figure shows performance of BER using IA based precoding in CP-OFDM, SC-FDE, ZP-only. Here the Block length of CP-OFDM, SC-FDE,ZP-only is N = 64 and CP or ZP length is 16. In IA based precoding ,the block length is N = 64,CP lengths are v = 16,0,8,12 when the independent information symbols are 64,56,60,62 respectively. For CP-OFDM, SC-FDE,ZP-only system, the IBI is completely removed when CP length is 16 and information symbols are 64. And it also shows when CP changes, the number of information symbol are also changed and this results valid with ref.[1].

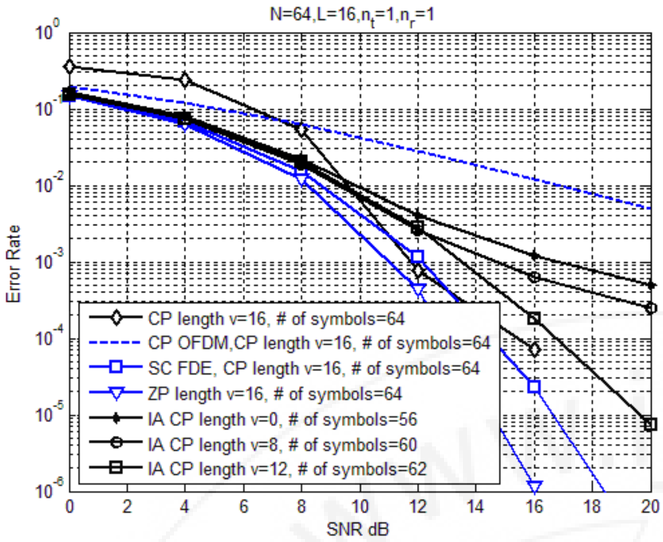

Figure 4: Performance of BER using IA based precoding in CP-OFDM,SC-FDE,ZP-only

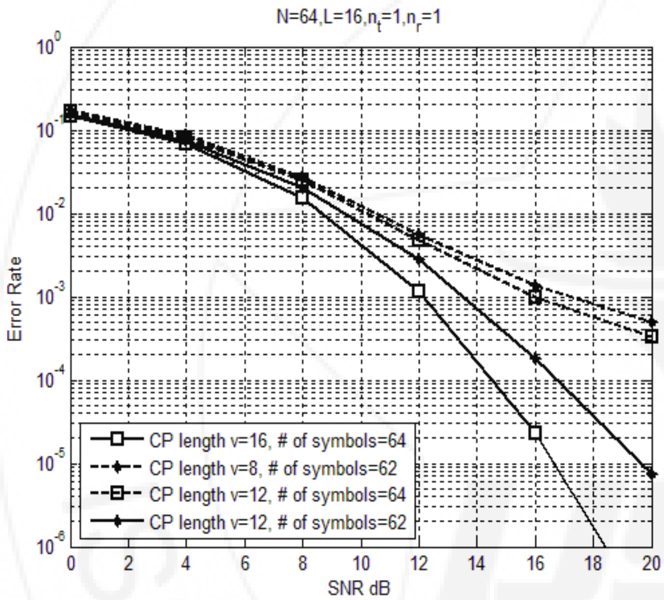

Figure 5: Performance of BER Using IA Based Precoding for Different CP Lengths and Different Number of information Symbols in SISO Case.

The Fig.5 shows the performance of BER using IA based precoding for different CP lengths and different number of information symbols in SISO case. When insuffient CP length v = 8,12 and the number of independent information symbols in one block is 62 and 64 respectively and their BER performance is dashed curve in Fig.5,where the error is occur and SNR becomes very high because IBI cannot completely eliminated and this results valid with ref.[1].

5. Conclusion

We conclude that using IA based precoding technique for different block based transmission system such as SC-FDE ,CP-OFDM and ZP-only, we have to remove complete IBI from SISO-OFDM. The BER performance is good, when SNR is very small. With insufficient CP or ZP added for CP-OFDM, SC-FDE and ZP-only,the error is also occur means there is residual IBI. We have to also using this IA based precoding for MIMO-OFDM system to check its BER performance.

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