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SYNCHRONIZATION ERROR SUPPRESSION AND PRECODER DESIGN IN OFDM CHANNEL

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ABSTRACT

Orthogonal Frequency Division Multiplexing (OFDM) is digital multi-carrier modulation technique which divides the whole channel into several orthogonal sub- channels. OFDM transmits a high data rate signal and offers high frequency efficiency, helps to increase robustness against Inter Symbol Interference (ISI) and fading caused by multi- path propagation. OFDM is chosen as air interface technique for LTE and it has high sensitivity. CA (Carrier Aggregation) is defined by 3GPP (the 3rd Generation Partnership Project) to support wide-bandwidth transmission. Carrier Frequency Offset (CFO) and Sampling Time Offset (STO) is a challenging problem in OFDM. Non continuous CA scenario's synchronization problem is addressed and CAZAC algorithm is proposed to suppress synchronization error, STO (Sampling Time Offset) and CFO (Carrier Frequency Offset). Precoder design is used to improve BER (Bit Error Rate) performance and to minimize the MSE (Mean Square Error Value).

Keywords: carrier aggregation; carrier frequency offset; OFDM; sampling timing offset; synchronization; cyclic prefix (CP), CAZAC.

1. INTRODUCTION

OFDM technology has become the core technology of the next generation mobile communication system because of the high bandwidth efficiency, the strong ability to resist inter-carrier interference and anti-channel interference. However, because OFDM system is a multicarrier modulation system, the system will be very sensitive to its synchronization errors. Synchronization estimation is an important part of the OFDM system. The main idea of OFDM technology is that the given channel is divided into many orthogonal sub-channels in frequency domain. Every sub-channel is modulated by one sub-carrier, and all sub- carriers are transported in parallel.

In order to guarantee the orthogonality of sub-carrier the guard interval or cyclic prefix (CP: Cyclic Prefix) are inserted among the sub-carrier in frequency domain. Through inserting guard interval or CP the interference among the OFDM symbols is eliminated. However, OFDM system is sensitive to time and frequency offset. Frequency offset will destroy the inter-carrier orthogonality which can cause ICI, and time offset will lead to the ISI. The good performance of the OFDM system is achieved by time and frequency synchronization. OFDM system synchronization mainly includes the timing synchronization, carrier frequency synchronization and sampling clock synchronization. The timing synchronization includes frame synchronization and symbol synchronization. The frame synchronization is used to determine the starting position of the data packet and the symbol synchronization is used to determine the starting position of OFDM symbols. For any digital communication system Synchronization is an essential task. It is impossible to recover the transmitted data without accurate synchronization algorithms. Timing and carrier frequency offset are the challenging problem in OFDM systems that too when combined with other multi access techniques such as FDMA, TDMA, and CDMA.

Local oscillator frequencies of modulators and the demodulator are aligned by the same, the orthogonality of the Subcarriers will be lost partially if any of these synchronization tasks is not performed with sufficient accuracy. That is, Intersymbol interference (ISI) and inter- carrier (ICI) are introduced. For any data communications system, the ability for the receiver to detect the transmission of a packet is a critical component. It is important to have packet detection algorithms to make this complicate; Fast Fourier Transform is used at the receiver end to make this process simple.

A precoder designed which combines statistical Channel State Information (CSI) at the transmitter, to minimize the Mean Square Error (MSE) and to nullify the interference inorder to gain a better performance compared to the channel independent precoding scheme in [1]. Carrier Aggregation(CA) technology is introduced by the 3GPP inorder to In order to achieve up to 1 Gb/s peak data rate in future IMT-Advanced mobile systems and to support very- high-data-rate transmissions over wide frequency bandwidths (e.g., up to 100 MHz) in its new LTE- Advanced standards. [2] and [3] focuses on the synchronization problems in non-continuous CA OFDM system and propose a novel block type pilot based synchronization errors suppression algorithm and without Carrier Frequency Offset (CFO) estimation the interference components are estimated with special property of the CAZAC sequence and also to get the right timing start point. Technical challenges for implementing CA technique in LTE-Advanced systems, with the requirements of backward compatibility to LTE systems, are highlighted and discussed. Possible technical solutions for the asymmetric CA problem, control signaling design, handover control, and guard band setting are reviewed in [4]. Discrete multitone (DMT) is a method of separating a Digital Subscriber Line (DSL) signal so that the usable frequency range is separated into

256 frequency bands (or channels) of 4.3125 KHz, DMT systems need the use of a guard interval (CP), to avoid ISI and ICI. This prefix produces a decrease in the achievable bandwidth efficiency to reduce this problem IIR linear precoder that adds memory in the time-domain and avoiding the need of a guard time is discussed shown in [5] [6]. New method for frequency offset estimation is described in [7] where the training sequence is composed of two Constant Amplitude Zero Auto Correlation (CAZAC) sequences in one OFDM symbol and the frequency offset up to OFDM bandwidth can be detected. The training sequence also can be used for channel estimation and equalization. Major Synchronization stages in OFDM are Symbol Timing Synchronization and Carrier Frequency Synchronization caused by ISI, ICI [8]. Mathematical analysis of the effect of timing errors on the performance of an OFDM receiver is provided in [9]. In order to meet the strong demand for wireless broadband services from fast-growing mobile users, the International Telecommunication Union (ITU) has initiated the standardization process of the next-generation mobile communication systems, entitled IMT-Advanced or fourth-generation (4G) mobile systems [10]. According to the performance and technical requirements defined in [11], future IMT-Advanced systems can support very high peak data rates for mobile users, up to 1 Gb/s in static and pedestrian environments, and up to 100 Mb/s in high-speed mobile environment.

2. PROPOSED SYSTEM

A. BLOCK DIAGRAM

The block diagram of proposed method is shown below, in which the channel coder high data rate RF signal is initially splitted into number of low frequency signals using serial to parallel convertor then it is modulated using QAM modulation scheme in this concept IFFT is to generate the subcarrier, used at the transmitter side which handles the signal in timed domain which divides the signal as Inphase and Quadrature phase. Guard bit is inserted inorder to avoid ISI in the transmitted signal. Then framing bits are inserted to the signal to provide synchronization between the channels. To transmit over the channel the signal is amplified using RF modulator amplifier. The receiver part is the inverse of the transmitter part, in this model of OFDM transceiver the error control scheme is used with the help of feedback network called frame detection scheme which detects the error in the transmitted signal and reduces it by sending feedback to the IFFT. This loop continues till it transmits the error free signal.

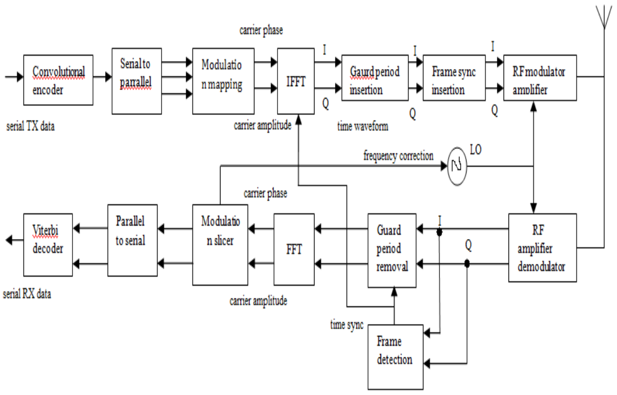

Figure-1. Block diagram of proposed method.

B. CARRIER AGGREGATION TECHNOLOGY

LTE-advanced comprises a set of features, while one of the most demanded feature is carrier aggregation (CA). LTE- advanced allows the aggregation of at a maximum five component carriers up to 20 MHz of bandwidth to attain a total transmission bandwidth of up to 100 MHz.

Carrier aggregation can be used for both FDD and TDD.

CA TYPES

- Continuous CA when multiple available component carriers are adjacent to each other
- Non-continuous CA when multiple available component carriers are separated along the frequency band.

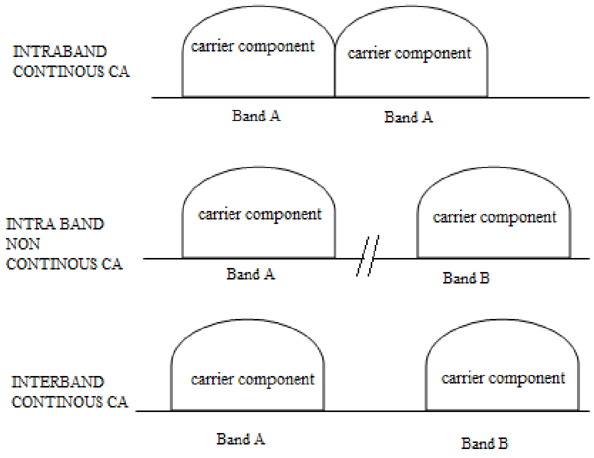

Figure-2. Types of Carrier Aggregation (CA).

In both cases multiple LTE/component carriers are aggregated to serve a single unit of LTE- Advanced UE. Regarding UE complexity, cost, capability, and power consumption, it is easier to implement continuous CA without making many changes to the physical layer structure of LTE systems. It is possible to use a single fast Fourier transform (FFT) module and a single radio frequency (RF) component to achieve continuous CA for an LTE-Advanced UE unit, while pro- viding backward compatibility to the LTE systems. In addition, compared to non-continuous CA, it is easier to implement resource allocation and management algorithms for continuous CA. Figure 2 shows the types of CA.

C. CONSTANT AMPLITUDE ZERO AUTOCORRELATION (CAZAC) FOR CA OFDM

A digital data source emits vectors x[k], where k indicates the discrete time. The source and channel coding are included in x[k], but not considered here. CAZAC digital bits is given to

$$\mathit{Matrix\ Interleaver}\ (x(k_{cb})(m,n))$$

$$x(k_{cb}) \underset{mat\ Int}{=>} (x(k_{cb})(m,n))$$

$$x_{k=} x_{\pi}(k) \tag{1}$$

Where $x\prod$ (k) is the function that describes the mapping of interleaver output time indices to interleaver time indices. Necessarily $\prod$ (k) for autocorrelation is one to one over the integer modulo its period of L samples. Because the periodicity $\pi(k) - L = \pi(k - L)$ the depth can be more precisely defined mathematically using the function $\prod$ as

$$x_{\pi}(k) = \underset{k\,=\,0,\ldots L-1}{min} \left|\pi^{-1} - \pi^{-1(k+1)}\right|$$

$$x(k_{cb})(m,n)=x_{\prod}(k) \tag{2}$$

The serial data stream is mapped into data symbols autocorrelation with a symbol rate of T=1, employing a general phase and amplitude modulation scheme, and the resulting symbol stream is de-multiplexed into a vector of N data symbols x_1 to x_N. Each of the resulting bits is multiplied with a spreading code sequence, which is Walsh-Hadamard code (C_b), where index b refers to the b_{th} column vector of with size of N x 1. These bits are modulated onto N subcarriers by an inverse discrete Fourier transformation (IDFT) correlation, which can be described as

$$F_{vp}^{-1} = \frac{1}{\sqrt{N}} e^{j\frac{2\pi}{N}(v-1)(p-1)} \tag{3}$$

Where j= sqrt (-1), v = 1; : : : ;N and p = 1,…,N. The parallel data symbol rate is (N*PG)*T=1, ie, the parallel symbol duration is N* PG times longer than the serial symbol duration T. Thus the effects of the dispersive channel become less damaging, affecting only a fraction of the extended signaling pulse duration

$$\underline{\breve{s}}[k] = \underline{\underline{F^{-1}}}_{b} \left(\underline{C_b} \otimes \underline{X}[k]\right). \tag{4}$$

Where the symbol $\otimes$ denotes element wise multiplication. The last l elements of the vector $\underline{\breve{s}}[k]$are copied and put as a cyclic prefix (CP) at the begin of the information block.

3. SIMULATION AND RESULTS

Table-1 describes the parameters used for simulation. QAM is used as its BER is low compared to other modulation techniques. The guard interval of 800 ns which provides robustness to root-mean-squared delay spreads up to several hundreds of nanoseconds, depending on the coding rate and modulation used.

Table -1. Parameters used.

PARAMETERS	VALUE
Data rate	6, 9, 12, 18, 24, 36, 48, 54 Mbit/s
Modulation	BPSK, QPSK, 16-QAM, 64-QAM
Coding rate	1/2, 2/3, ¾
Number of subcarriers	52
Number of pilots	4
OFDM symbol duration	4 µs
Guard interval	800 ns
Subcarrier spacing	312.5 kHz
-3 dB Bandwidth	16.56 MHz
Channel spacing	20 MHz

Two channels are considered for bit error performance with respect to CFO. Figure-3 and Figure-4 shows the BER performance when SNR is 10dB the proposed algorithm has the same performance when CFO increases.

In AWGN channel no offset lies between 10^{-2} and 10^{-3} where overlap occurs in pedB channel. From BER performance of the two channels Ped B and AWGN there occurs suppression reduced in 10^{0} where full matrix suppression varies with 10^{-1} to 10^{-2} ped B and 10^{-2} to 10^{-3} in AWGN.

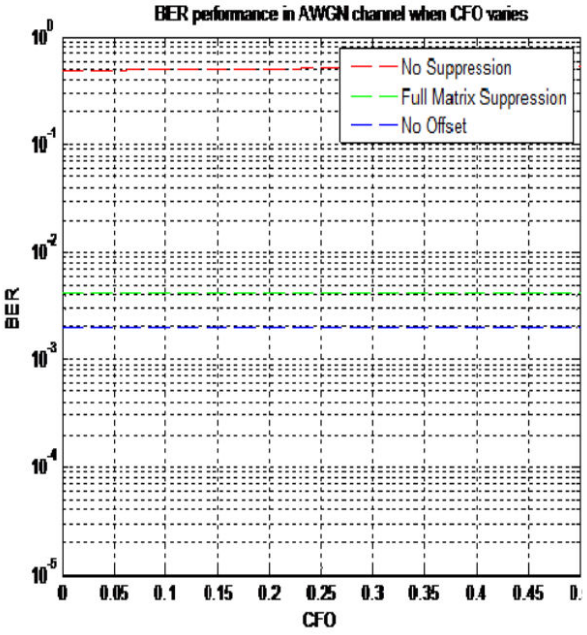

Figure-3. BER performance of AWGN channel.

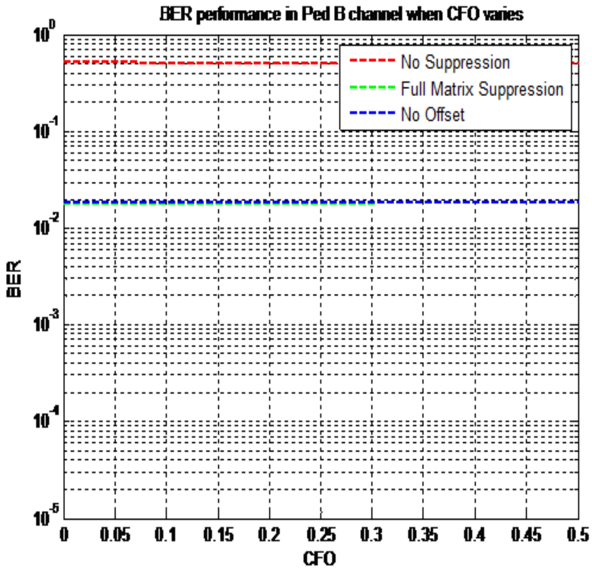

Figure-4. BER performance of pedB channel.

In Figure-5, BER of SC-FDE-single carrier frequency domain equalization, ZP zero padding, Stat CSIT-statistical channel state information transmitter are simulated. Where the CP length is 16 i.e. guard interval is sufficient for our channel with number of symbols is 64. CSIT performance can be improve the BER performance compared to the previous precoding. The SC-FDE and zp does not coincides with the independent precoder with number of symbols as 56 the above Figure for SISO case. Figure-6 shows the BER performance for the CSIT in MIMO case where number of symbols=64, length =20 of CSIT. The SNR value is increased up to 35 where BER lies in the range of 20-25 dB except precoder length=6, 8 for 62 symbols

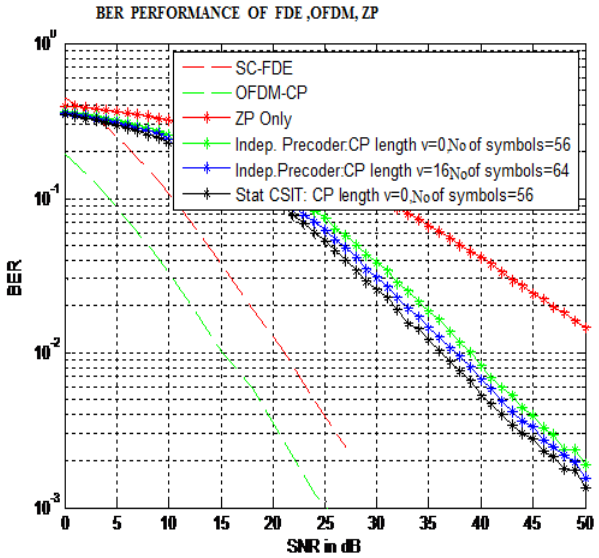

Figure-5. BER performance of FDE, OFDM, ZP.

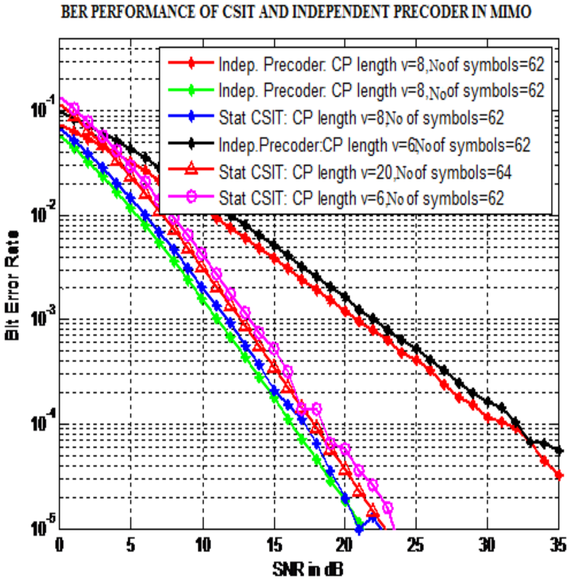

Figure-6. BER performance of CSIT in MIMO.

4. CONCLUSIONS

Thus the suppression of synchronization error in OFDM channel by CA technology for CFO and STO are simulated. BER performance of two channels AWGN, pedB channels are also discussed.BER of independent decoder with symbols of 64 varies with length .In future the comparison can be made between the ped B channel and any other channel. The velocity, bandwidth of the channels can also be calculated in order to improve the performance.

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