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Design of Modified Timing Offset Estimation in OFDM for Maintaining Orthogonality

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Abstract – This paper deal with the symbol timing issue of an OFDM system in fast varying channel. Symbol timing offset (STO) estimation is a major task in OFDM. Most of existing methods for estimating STO used cyclic prefix or training sequences. In this paper, we consider a new system for STO estimation using constant amplitude zero auto-correlation (CAZAC) sequences as pilot sequences in conjunction with fractional Fourier transform (FRFT). This method gives good results in terms of MSE in comparison with other known techniques and it is important for fast varying channel. MATLAB simulations are used to evaluate the performance of the proposed estimator.

Index Terms – STO: Symbol Timing Offset, OFDM: orthogonal Frequency Division Multiplexing, MIMO: Multiple Input Multiple Output, CAZAC: Constant Amplitude Zero Auto Correlation, ISI: Inter Symbol Interference ,ICI: Inter carrier Interference.

1. INTRODUCTION

The technique to allow the mobile users to share a common medium simultaneously in an effective and in efficient manner can be defined as multiple accesses. The major types of multiple access techniques are FDMA, TDMA and CDMA. In this paper, we implement an OFDM Transmitter with CAZAC sequences as pilot sequences and Fractional Fourier Transform. In reception, STO estimator is implemented. The remainder of this paper is organized as follows. In section 2, we introduce OFDM signal and the effect of STO. Then, we present Fractional Fourier Transform in section 3. Thereafter, Section 4 shows the proposed method. Finally, the last one shows the performance of this technique in terms of MSE

There are the different timing offset estimation methods which are based on the training symbol transmission. These are generally called it as a data added methods. Before the transmission of actual information data symbols, preambles are actually transmitted for timing synchronization in the case of data added methods. The timing estimation algorithm helps to find the maxima of auto-correlation of the incoming signal which helps to detect the starting point of the training symbol. There are many more methods related to the timing offset estimation. Some of the timing offset estimation methods are described below on the basis of their training symbol patterns and the timing metric. We basically describe about the fine timing estimation.

Schmidl and Cox Method: Timing synchronization in Schmidl and Cox method is obtained by using a training sequence where the time domain of the first half is equal to its second half.

Minn and BhargavaMethod: In order to reduce the uncertainty to evaluate the correct timing Minn and Bhargava proposed the another method The Minn's method has a fine timing metric which has its peak better than that of Schmidl and Cox at the correct starting point of the OFDM symbol.

Byungjoon Park Method: This is simply the reverse auto-correlation method. In order to avoid the ambiguity which has been occurred in Schmidl and Cox as well as in the minn's timing offset

An even sharper timing metric is produced from park than from schmidl and minn's but the timing metric produced by park has its two large side lobes which will affect the timing performance. Between two adjacent values different pairs of product are designed by parks so that the timing metric has its peak value at the correct symbol timing where the values at all other positions remains almost zero.

OFDM is the growing demand among the latest technology which has always been the area of interest. It's been more concern for the better quality. Besides great achievement, there are some certain issues which have always been the scope of study

Timing synchronization:The ultimate task of finding the precise moment of the individual OFDM symbols start and the end is the Symbol Synchronization. It refers to the timing errors and carrier frequency offset which is highly sensitive in OFDM system. High sensitivity is due to the use of IFFT and FFT for modulation and demodulation at transmitter and receiver side as per their respective point. To recover these errors various algorithms have been proposed which are discussed in the next chapter.

Frequency synchronization: It refers to the sampling frequency synchronization and carrier frequency synchronization. Carrier frequency offset arises between the sub-carriers if the orthogonality between the sub-carriers will be destroyed.

High peak to average power ratio: Efficiency will be reduced by high PAPR which degrades the total performance of the system.

2. METHODOLOGY

Symbol timing offset effects: Symbol timing estimation in OFDM system helps to find the starting point of the FFT window at the receiver side. The effects of STO are determined depending on the location of the estimated starting point of OFDM symbol. There are four different cases of timingoffset which is illustrated below.

Case I: consider the case when there is no timing error. First case refers to that when the estimated starting point of the OFDM symbol coincides with the exact timing preserving the orthogonality among the subcarriers so that the OFDM symbol can exactly be recovered without having any types of interference.

Case II: The next case is when the estimated starting point of the OFDM symbol is before the exact point, yet after the end of the channel response to the previous OFDM symbol.

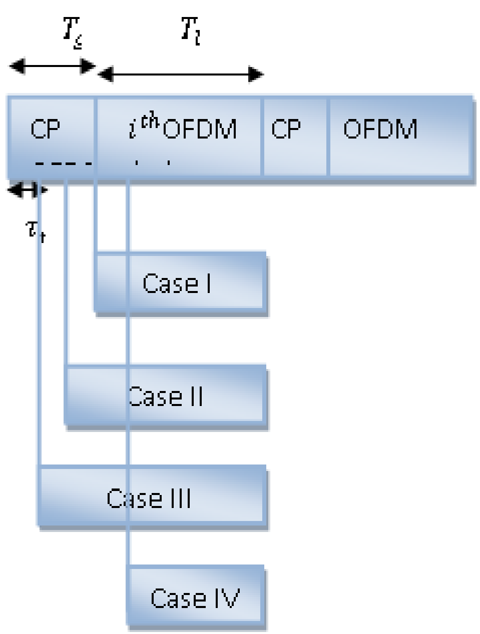

Fig. 1: STO effects in different cases

Case III: This one is the Case prior to the end of the (lagged) channel response to the previous OFDM symbol when the starting point of the OFDM symbol is estimated to exist. This will allow the symbol timing avoid the ISI too early. ISI will led the orthogonality among the sub-carriers destroyed from the previous symbol which will led them to occur ICI.

Case IV: The fourth case is that when the starting point of the OFDM symbol is estimated just after the exact point.

3. METHOD ADAPTED

In this section, the proposed method is presented. CPbased STO estimation techniques is been used.For estimating STO, CP and the data part which is the replica of the OFDM symbol will share their resemblances. The two sliding windows having W_1 and W_2can slide to get the similar connection amongst the samples within the windows. The similar connection in between the blocks of CP and the data parts when taken into the sliding windows will take full advantage of getting maximized if CP in an OFDM symbol enters into the beginning of the sliding window. The points which get maximized will help to detect the STO.

If the differences between the CP block and the data parts block is minimized then the similar connection in-between these bocks located in the sliding windows will get maximized. The estimated STO can be obtained by examining the related points so as to sort out by taking the differences between CP blocks and the data part bocks of having N_G samples within the specified sliding windows which is minimized. The mathematical expression can be expressed as

$$\hat{\delta} = argminmin_{\delta}\left(\sum_{i=\delta}^{N_G-1+\delta} |yl[n+i] - yl[n+N=i]|\right)$$

If there is the existence of CFO then the performance of the system will be degraded so we approached for the another estimation technique which can take the CFO as the estimating technique which helps in minimizing the differences of the N_G samples of CP in window W1 and the conjugate part in the second window taking its square which can be represented by the equation as

$$\hat{\delta} = argminmin_{\delta}\left\{\left(\sum_{i=\delta}^{N_G-1+\delta} |yl[n+i] - yl[n+N=i]|\right)^2\right\}$$

ML estimation is applied to the end by considering the correlation between the two blocks applied in the two sliding windows

A conventional OFDM system is used but Fractional Fourier Transform FRFT block is used instead of classical FFT. We use Constant Amplitude Zero Auto Correlation (CAZAC) sequences as pilot sequences. The Timing Offset estimation is done in frequency domain. Estimated STO is obtained by multiplying the received pilot sequences (with STO) by the conjugated pilot sequence. CAZAC sequences used in this thesis are defined as:

$$X_p\left((k-1) * N_{ps} + 1\right) = e^{j\pi(k-1)^2/N_p}$$

For k= 1, 2, 3 …..N_p

The proposed receiver schema is given by figure 4.3, To evaluate the performance of the proposed methods, computer simulations are established. Parameters of this simulation are listed in Table II. Figure 3.2 shows the Mean Square Error (MSE) of the symbol timing Offset (STO) of the OFDM system using Fractional Fourier Transform and CAZAC sequences. This figure shows the superiority of the proposed system in terms of

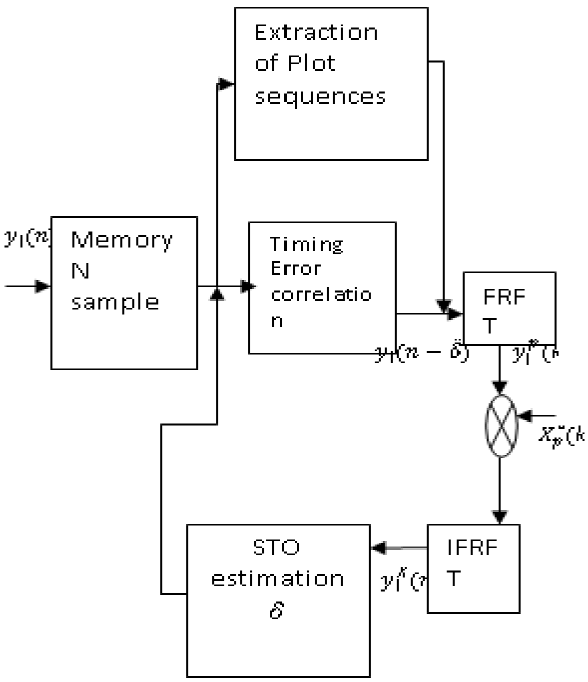

Figure 2 STO synchronization scheme using pilot tones

Proposed design use auto correlation and Thresholding based algorithm to find out the similar samples and based on this work the offset time is been assigned to the symbols we need to reduce offset time between samples and concept is we reduces the offset time between similar signals and increase the offset between non-similar signals.

4. RESULTS

Parameter Average Value	**Modulation**		
	4 PSK	**16 PSK**	**64 PSK**
BER	0.00000522	0.000247	0.00124
MSE	0.00138	0.061	0.31
SNR	76.96	60.22	53.21
STO	0.0000307	0.000152	0.00064

Table 1 Obtain results

	Proposed	**Zhang Xing**	**Sucharita Chakraborty**	**Ali Baghaki**
BER	0.00000522	0.0000741	0.0000137	-
MSE	0.00138	0.00862	0.00438	0.00736
SNR	76.96	70.54	71.82	72.69
STO	0.0000307	0.000498	0.000347	0.0000972

Table 2 Comparative results

5. CONCLUSION

This thesis proposes a new symbol timing offset (STO) estimation that uses CAZAC sequences as pilot sequences in conjunction with Fractional Fourier Transform. The main design criterion of this method is to exploit the well-known efficiency of both CAZAC sequences and FRFT in reducing MSE of STO of the designed system. The system we designed shows attractive performance and stands useful for mobile fast varying channels. Proposed work is basically a CP based STO estimation techniques is been used.For estimating STO, CP and the data part which is the replica of the OFDM symbol will share their resemblances.Thesis deals with the symbol timing issue of an OFDM system in fast varying channel. Symbol timing offset (STO) estimation is a major task in OFDM. Most of existing methods for estimating STO used cyclic prefix or training sequences.

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