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CARRIER FREQUENCY OFFSET ESTIMATION IN MIMO OFDM SYSTEMS

D. Kayalvizhi[3],N.Nagavalli[4]
J.Arivazhagan[5]
(Final Year/Department of ECE)
K.Sureshkumar(AP/ECE)[1], J.Rajalakshmi (AP/ECE)[2],
CK College of Engineering and Technology, Cuddalore – 3.

m.k.sureshkoumar@gmail.com[1], raji.ckcet@gmail.com[2],
kayalck94@gmail.com[3], nagavalli.raji@gmail.com[4]
arivazhagan1312@gmail.com[5]

ABSTRACT:-Orthogonal frequency division multiplexing (OFDM) has been selected for broadband wireless communication system. OFDM can provide large data rates with sufficient robustness to radio channel impairments. One of the major drawbacks for OFDM system is Carrier frequency offset (CFO). Frequency offset has been recognized as a major disadvantage of MIMO OFDM. The OFDM systems are sensitive to the frequency synchronization errors in form of Carrier Frequency Offset (CFO), because it can cause the Inter Carrier Interference (ICI) which can lead to the frequency mismatched in transmitter and receiver oscillator. To compensate the effect of CFO we have propose various CFO estimation and compensation techniques and algorithms by now. In this project, exploiting the reason of creating CFO and the effects of the CFO on the performance of the OFDM systems by simulation.The major CFO estimation algorithm and techniques will be reviewed and discussed in literature briefly for estimating and compensation of the effect of CFO will be offered.Carrier frequency offset (CFO) is one of most well-known disturbances for OFDM. It generates inter-carrier interference (ICI) and degrades OFDM performance. In order to mitigate the negative influence, CFO is usually estimated and compensated accordingly during OFDM system. While its performance degrades in multi-path dispersive channel. In general, it provides better accuracy than STO. In order to reduce the noise effect, itsaverage can be taken over the samples in a Cyclic Prefix(CP) interval.

Keywords: Carrier frequency offset (CFO), Orthogonal Frequency Division Multiplexing (OFDM),MIMO(Multi Input Multi Output), Inter Carrier Interference (ICI), CFO Estimation, Cyclic prefix(CP).

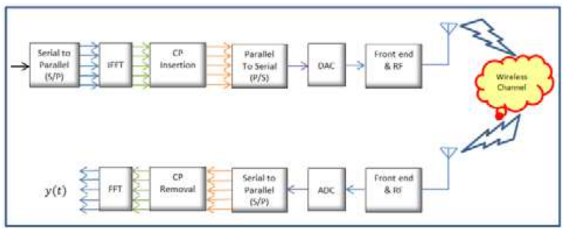
1.INTRODUCTION

The orthogonality of the OFDM relies on the conditionthat transmitter and receiver operate with exactly the samefrequency reference. If this is not the case, the perfectorthogonality of the subcarrier will be lost, which canresult to subcarrier leakage, this phenomenon is alsoknown as the Inter Carrier Interference (ICI) . In another word, the OFDM systems are sensitive to the frequency synchronization errors in form of CFO. CFOcan lead to the Inter Carrier Interference (ICI); therefore CFO plays a key role in Frequency synchronization. Basically for getting a good performance of OFDM, the CFO should be estimated and compensated. Lack of the synchronization of the local oscillator signal fordown conversion in the receiver with the carrier signal contained in the received signal causes Carrier Frequency Offset (CFO) which can create the following factors:

(i) Frequency mismatched in the transmitter and thereceiver oscillator

(ii) Inter Carrier Interference (ICI)

(iii) Doppler Effect (DE)



Block diagram of the OFDM system

2. Carrier Frequency Offset (CFO)

The OFDM systems are very sensitive to the carrierfrequency offset (CFO) and timing, therefore, beforedemodulating the OFDM signals at the receiver side, the receiver must be synchronized to the time frame and carrier frequency which has been transmitted. Of course, In order to help the synchronization, the signals that are transmitted, have the references parameters that are used in receiver for synchronization. However, in order the receiver to be synchronized with the transmitter, it needs to know two important factors:

(i) Prior to the FFT process, where it should startsampling the incoming OFDM symbol from.
(ii) How to estimate and correct any carrier frequencyoffset (CFO).

3. Effects of CFO on OFDM signals

When CFO happens, it causes the receiver signal to beshifted in frequency (δf); this is illustrated in the figure . If the frequency error is an integer multiple of subcarrier spacing δf, then the received frequency domain subcarriers are shifted by δf. On the other hand, as we know the subcarriers (SCs) will sample at their peak, and this can only occur when there is no frequency offset, however if there is any frequency offset, the sampling will be done at the offset point, which is not the peak point.

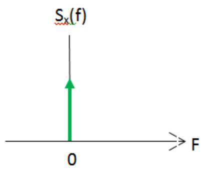


Figure1

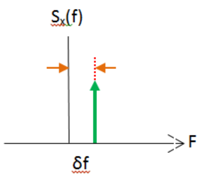
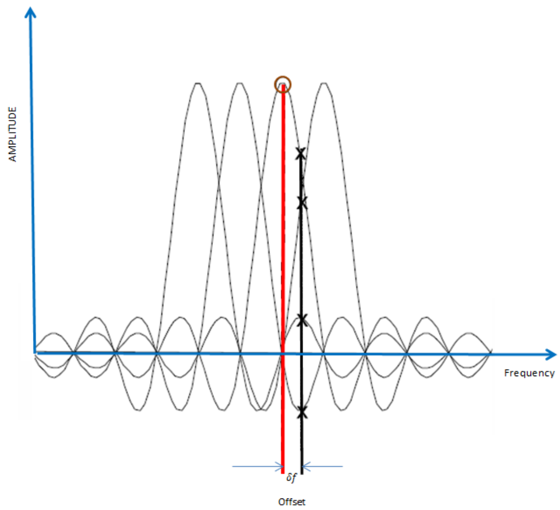


Figure2

This causes to reduce the amplitude of the anticipated subcarriers, which can result to raise the Inter Carrier Interference (ICI) from the adjacent subcarriers (SCs). Figure 2 shows the impact of carrier frequency offset (CFO).It is necessary to mention that although it is true that thefrequency errors typically arise from a mismatch between the reference frequencies of the transmitterand the receiver local oscillators, but this difference isavoidable due to the tolerance that electronics elements have. Therefore there is always a difference between the carrier frequencies that is generated in the receiver with the one that is generated in transmitter; this difference is called frequency offset .

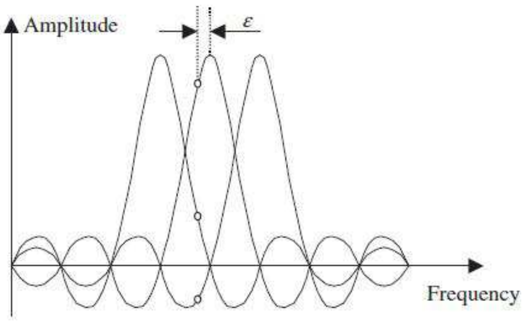


Frequency offset

The baseband transmit signal is converted up to the passband by a carrier modulation and then, converted down to the baseband by using a local carrier signal of (hopefully) the same carrier frequency at the receiver. In general, there are two types of distortion associated with the carrier signal. One is the phase noise due to the instability of carrier signal generators used at the transmitter and receiver, which can be modeled as a zero-mean Wiener random process. The other is the carrier frequency offset (CFO) caused by Doppler frequency. CFO destroys the orthogonality between the sub-carriers.The effect of the CFO in receiving signal in frequency domain with shiftingof and time domain multiplying with the exponential term

4. CYCLIC PREFIX (CP):

The OFDM guard interval can be inserted in two different ways. One is the zero padding (ZP) that pads the guard interval with zeros. The other is the cyclic extension of the OFDM symbol (for some continuity) with CP (cyclic prefix) or CS (cyclic suffix). CP is to extend the OFDM symbol by copying the last samples of the OFDM symbol into its front. OFDM symbols have CPand ISI efect of a multipath channel for each sub carrier. Cyclic prefix should be greater than delay spread of channel to avoid inter OFDM symbol interference. CP is simply repeating symbols dost not constitute any information, hence the effect of addition of long CP is loss in throughput of system.



Inter-carrier interference subject to CFO

5. CFO estimation algorithm

CFO can produce Inter Carrier Interference (ICI) which can be much worse than the effect of noise on OFDM systems. That's why various CFO estimation and compensation algorithms have been proposed. For showing the importance of it, it is enough to mention that, by now the researchers have proposed numerous and various CFO estimation and compensation techniques and algorithms, which is

1.Blind estimation algorithm

5.1. Blind estimation algorithm

Another algorithm that has been used is called Blind CFO estimation algorithm. In these algorithms by using the statistical properties of the received signal, the CFO will be estimated. Since the receiver doesn't have any knowledge of the signal that the transmitter has been sending, therefore the blind algorithms are considered to have a high computational complexity. In compared with training based algorithm, blind algorithms have no need to the training sequences; therefore there is no training overhead for these algorithms.

Although ISI can be avoided, via the use of cyclic prefix in OFDM modulation, the phase and gain of each subchannel is needed for coherent symbol detection. An estimate of these parameters can be obtained with pilot/training symbols, at the expense of bandwidth. Blind channel estimation methods avoid the use of pilot symbols, which makes them good candidates for achieving high spectral-efficiency. Existing blind channel estimation methods for OFDM systems can be classified as:

1. Statistical
2. Deterministic

The statistical methods explore the cyclo-stationarity that the cyclic prefix induces to the transmitted signal. They recover the channel using cyclic statistics of the received signal, or subspace decomposition of the correlation matrix of the pre-DFT received blocks. The deterministic methods process the post DFT received blocks, and exploit the finite-alphabet property of the information bearing symbols. Maximum likelihood and iterative Bayesian methods are two examples. Taking into account, specific properties of M-PSK or QAM signals, while utilizing an exhaustive search. In comparison to the statistical methods, the deterministic ones converge much faster, however, they involve high complexity, which becomes even higher as the constellation order increases.

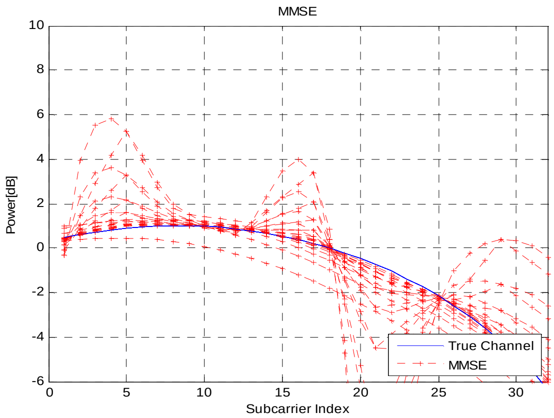
6. Investigating of the estimation Technique using Cyclic Prefix (CP)

This technique uses the length of Cyclic Prefix (CP) to compensate the effect CFO. The signal received by receiver can be stated as Where is propagation delayand is initial phase, is CFO and is Additive White Gaussian Noise (AWGN) In receiver side, the OFDM demodulator removes the CP and considers the sample vector .Here the goal is to exploit the redundancy of Cyclic Prefix (CP). Finally by using these results you can compensate the effect of the CFO. This method has a good efficiency and a linear complexity.For the whole OFDM blocks we only need to determine one time. Therefore the computational complexity of this method is linear which makes it an effective technique but the CFO estimation technique using CP, is only and only good. Due to the weakness of the CFO estimation using CP, and improving it for the amounts of which are greater than the mentioned values, we offer using training symbols. Before we start, firstly we need to select a signal model therefore the first step in our algorithm is: selecting signal model. Let's consider an OFDM-MIMO system, with transmitter and receiver antennas as follows: Multi-user MIMO-OFDM system .

7. Robustness to Carrier Frequency Offset

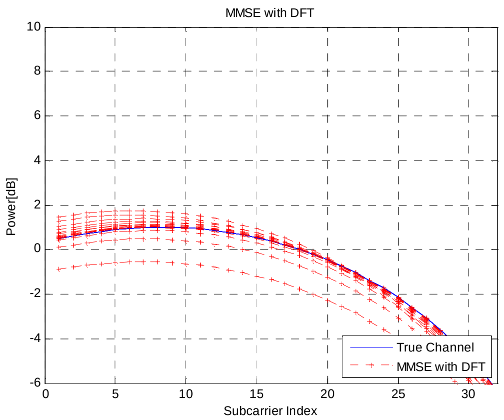
In a practical system, the symbol timing needs to beacquired prior to all other operations in the receiver. The received OFDM signal might be disturbed by a CFO . Therefore, it is crucial that a symbol timing estimator is robust. theamplitude of the received signal, the influence of the CFOis excluded.

8. NUMERICAL METHOD



Subcarrier vs Channel Information

The figure shows power required to estimate the channel conditions. The plot is for subcarrier index versus power needed to get the channel state information. Here MMSE shows a variation in power requirement in estimating the channel.



Subcarrier vs Channel Information

The figure shows power required to estimate the channel conditions. The plot is for subcarrier index versus power needed to get the channel state information. Here MMSE with DFT needs less power compared to MMSE for estimating the channel.

9. FUTURE SCOPE

The work that has been done in this thesis involves the algorithms that basically deal withthe rectification of the problem of frequency synchronization which is the major obstruction in the pathway of practical implementation of OFDM systems. We also concluded that phase lock loop (PLL) should be included in the estimator to increase the accuracy and stability of estimated frequency and phase offset. Further demanding research is needed in MIMO-OFDM system allowing for the generalized system model, where the CFO and propagation delay between each transmit antenna and receive antenna are possibly different. Recently, a new OFDM system based on a combination of CDMA and OFDM signalling, referred to as MC-CDMA system, has gained much attention. A MC-CDMA system can provide higher capacity for multiple accesses and still hold the advantage of OFDM such as robustness for frequency selective fading. Hence, the synchronization scheme under MC-CDMA system is also worth of future study.

10. CONCLUSION

In this paper, we presented an CFO estimator using a blind estimation. Simulation results show that the modified method provides considerable improvements in terms of estimation performance and system throughput in a low to medium SNR region compared to the orinal transition metric based estimator

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