International Journal of Scientific Research & Engineering Trends
Volume 3, Issue 1, Jan.-2017, ISSN (Online): 2395-566X

Carrier Frequency Offset Estimation in OFDM Systems: Review

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***Abstract* – The wireless system for communication uses the orthogonal frequency division multiplexing in these days. OFDM is used for transferring the high data rate. But there are some disadvantages of OFDM one of them is Carrier frequency offset. The cause behind the CFO is the synchronization between frequencies. It is a very sensitive so that hard to manage these frequencies. This paper is an overview about the OFDM and the selection of the proper frequency for data transmission. This paper also throws some light on the previous work of OFDM.**

***Keywords* – OFDM Frequency Estimation, Carrier Frequency Offset.**

I. INTRODUCTION

The rapid growth of high data rate transmission makes a need to improve the performance of a network. This can be made easy by using Orthogonal Frequency Division Multiplexing. OFDM is a approach in which the multicarrier transmission technique have been used for wireless communication. Here the high data rate has been use to transmit the data. This high data can be divided into various sequences of the data. These sequences can be concurrently transmitted by the sub carriers. The IEEE 802.11a includes the OFDM as a standard due to its robustness under multipath fading conditions.

The history of OFDM say that it was first introduced in the 1950s. Initially the OFDM techniques were used in defense or military systems around in 1960s. The 1980s was the time where high-speed modems, digital mobile communications, high-density recording etc were in used. So OFDM was involved in improving the performance of these systems. Finally in the 1990s, OFDM was drastically user in the mobile communications. Here it was use for the wideband as a FM channel. DSL, ADSL, VDSL, DAB were the implementation area of OFDM.
This paper is divided into

II. ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING

As earlier section it seems to be that the Orthogonal Frequency Division Multiplexing is approach in order to provide the fast service during the communication network. It can achieve by the concept of subcarrier in which the parallel transmission can possible. Here is a block diagram of transmitter and receiver for the OFDM.

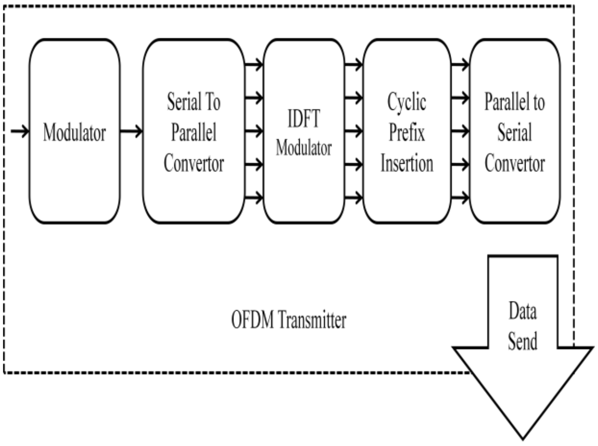

Fig.1. Transmitter for OFDM

The figure 1 shows the transmitter of the OFDM System. There are some small component has used like modulator serial to parallel convertor etc.

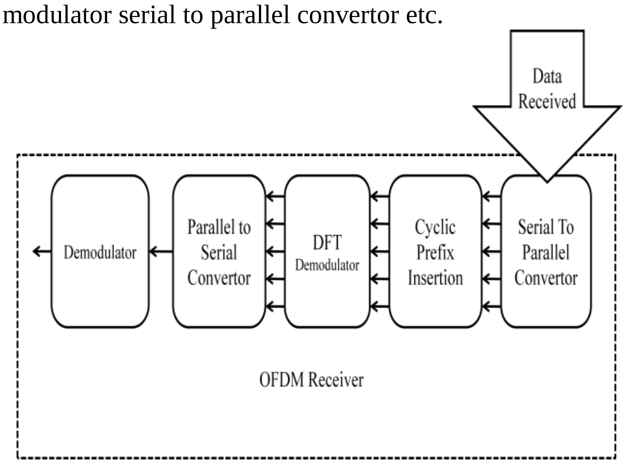

Fig.2. Receiver of OFDM

This block diagram is implemented for the receiver of the end user. It is a reveres process of the transmitting end.

III. Properties of OFDM

There are various property which has the OFDM. Some of them has discuss are discussed here.

Reduced computational complexity:

OFDM can be easily implemented using FFT/IFFT and the processing requirements grow only slightly faster than linearly with data rate or bandwidth the computational complexity of OFDM can be shown to be, where B is the bandwidth and Tm is the delay spread. This complexity is much lower than that of a standard equalizer-based system, which has a complexity.

- **Graceful degradation of performance under excess delay:**

The performance of an OFDM system degrades gracefully as the delay spread exceeds the value designed for greater coding and low constellation sizes can be used to provide fallback rates that are significantly more robust against delay spread.

In other words, OFDM is well suited for adaptive modulation and coding, which allows the system to make the best of the available channel conditions. This contrasts with the abrupt degradation owing to error propagation that single-carrier systems experience as the delay spread exceeds the value for which the equalizer is designed.

- **Exploitation of frequency diversity:**

OFDM facilitates coding and interleaving across subcarriers in the frequency domain, which can provide robustness against burst errors caused by portions of the transmitted spectrum undergoing deep fades. In fact, WiMAX defines subcarrier permutations that allow systems to exploit this.

- **Use as a multiaccess scheme:**

OFDM can be used as a multiaccess scheme, where different tones are partitioned among multiple users. This scheme is referred to as OFDMA and is exploited in mobile WiMAX. This scheme also offers the ability to provide fine granularity in channel allocation. In relatively slow time-varying channels, it is possible to significantly enhance the capacity by adapting the data rate per subscriber according to the signal-to-noise ratio of that particular subcarrier.

- **Robust against narrowband interference:**

OFDM is relatively robust against narrowband interference, since such interference affects only a fraction of the subcarriers.

- **Suitable for coherent demodulation:**

It is relatively easy to do pilot-based channel estimation in OFDM systems, which renders them suitable for coherent demodulation schemes that are more power efficient. Despite these advantages, OFDM techniques also face several challenges.

IV. Classification of Frequency Offset Estimation

The frequency offset estimation is a challenging task due to its complexity. So there are two basic approaches by which the frequency estimation in OFDM is possible.

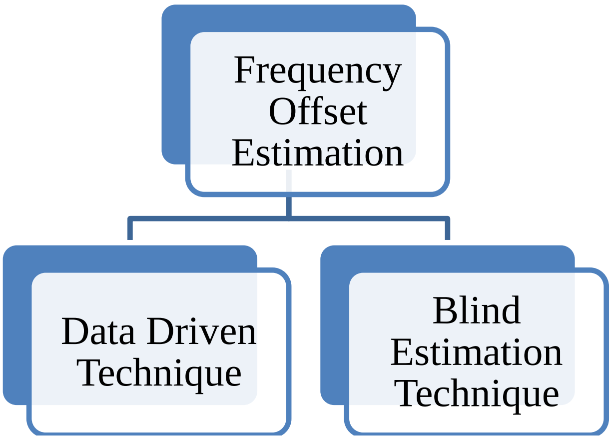

Fig.3. Classification of frequency offset

Data Driven Technique

The effects of frequency offset will show on the performance of OFDM systems. A frequency offset of more than 0.4% of the frequency spacing yields unacceptable system performance. The data-driven technique estimates the frequency offset from the repetition of the same data frame by maximum likelihood. The OFDM signal at the receiver is given by.

$$r_n = (1/N) \sum_{k=-K}^{K} X_k H_k e^{2\pi jn\,(k+\varepsilon)/N}$$

Where n=0, 1, 2…..N-1

Where X = Transmitted Signal,

H= Transfer Function over carrier

$$\varepsilon = Frequency\ Offset$$

There is need to calculate the difference of data frames in order to get the frequency offset

Blind Estimation

The blind technique is focused on determining both frequency and timing offset. The timing offset is another significant issue for OFDM systems. The blind technique estimates the frequency offset by analyzing the signal at the receiver. For a QPSK signal, if there is no offset and no noise, the exact QPSK signal is received at the receiver. If there is a frequency offset in the channel, the constellation is rotated by a phase proportional to the offset.

V. Related Work

This paper [5] presents frequency offset estimation algorithm in wireless OFDM cellular system such as 3G-LTE. We first analyze the method of frequency offset estimation in general OFDM system. The analysis will show that the value of frequency offset estimation in cell boundary is inaccurate. Because doppler frequencies of signals transmitted from different base stations are different, the error of frequency offset estimation value is generated. We show how proposed algorithm can reduce the error of frequency offset estimation. Results of simulation show that the utilization of proposed algorithm can reduce the error of frequency offset estimation considerably. Proposed frequency offset estimation algorithm can increase overall system capacity because of performance improvement in cell boundary. Especially, 16-QAM or 64-QAM modulations for high data rate transmission is extremely sensitive to frequency offset, therefore proposed algorithm increases channel capacity for user in cell boundary.

A new joint frame [6] synchronization and carrier frequency offset estimation scheme in orthogonal frequency division multiplexing (OFDM) systems is proposed in this paper, where both frame synchronization and carrier frequency offset estimation can be performed by using only ONE training symbol. Frame synchronization and carrier frequency offset acquisition are performed simultaneously in the proposed scheme. Reliable frame synchronization is obtained in the proposed scheme even in low SNR. The maximum carrier frequency offset acquisition range of the proposed scheme can be up to one half of the total signal bandwidth. The same training symbol can also be utilized to carrier frequency offset Fine Adjustment, which estimates the remaining carrier frequency offset after acquisition with higher accuracy. The performance comparison of the proposed Fine Adjustment algorithm and Schmidl's algorithm by using computer simulation illustrates and verify the superior performance of the proposed algorithm with regard to estimation accuracy.

This paper [7] presents a basic useful technique for carrier frequency offset (CFO) estimation in orthogonal frequency division multiplexing (OFDM) over frequency selective fading channel. The performance of OFDM system is very sensitive to CFO, which introduces inter-carrier interference (ICI). In cyclic prefix (CP) based estimation, the CFO can be found from the phase angle of the product of CP and corresponding rear part of the OFDM symbol. In CFO estimation using training symbol, the CFO estimation range can be increased by reducing the distance between two blocks of samples for correlation. This was made possible by using training symbol that are repetitive with shorter period. An analytic expression in form of mean square error (MSE) of frequency offset synchronization is reported, and simulation results verify theoretical analysis.

This work [8] considers the effect of timing errors on the carrier frequency offset (CFO) estimation for orthogonal frequency division multiplexing (OFDM) systems. In general, most of the research conducted on OFDM systems assume that a wide range of timing errors can be tolerated due to the use of cyclic prefix (CP). Although such assumption might be valid for bit error rate (BER) analysis, it might not be the case for other processes such as CFO estimation. In this work, Monte Carlo simulations have been used to evaluate the effect of timing errors on the performance of several state-of-the-art CFO estimators for OFDM systems. The considered estimators include time domain, frequency domain, data-aided (DA) and blind estimators. Simulation results confirmed that particular CFO estimators, which are known to be highly accurate in perfect timing conditions, are very sensitive to timing offsets even if the offsets are within the inter-symbol-interference (ISI) free region of the CP. Other estimators offered high robustness for timing offsets in the entire range of the CP region. However, most of the considered estimators suffered from severe performance degradation for timing errors out of the CP region.

For Orthogonal frequency division multiplexing (OFDM) systems [9], the bandwidth is divided into many subcarriers, requiring a highly accurate frequency offset estimator. In this paper, a novel frequency offset estimator utilizing the periodicity embedded in a training symbol is proposed. We generalize the well known correlation-based methods such that the estimation range of all the correlations embedded in a training symbol can be extended to the maximum. These correlations can thus be utilized freely without degrading the estimation range. Since only one training symbol is needed, the transmission efficiency is increased. The proposed method needs only the periodicity of the training symbol which leaves the design of pilot symbol for other considerations such as timing synchronization and channel estimation. To implement this estimator, a low-complexity algorithm is introduced. Performance analysis and simulation results are both given to compare with previously proposed best linear unbiased estimator (BLUE) and the superiority of our proposal is witnessed.

In this paper [10], two fast and accurate FFT-based frequency offset estimation methods for OFDM systems are proposed. The author has analyzed and simulate proposed methods in both Gaussian and multipath fading channels, and compare the results with those obtained using well known Schmidl's method. The simulation results are presented in terms of Error Variance (EV). Both proposed FFT-based methods have significantly smaller EV than Schmidl's method in AWGN and Multipath static fading channel and the proposed FFT method-II also has smaller EV than Schmidl's method in multipath time-varying fading channel.

VI. CONCLUSION

OFDM is an emerging field in the world of wireless communication. In this way there are lots of challenges are also in front of us. This paper is a brief description on the OFDM and their issues. These are lots of problem have to face in the frequency offset estimation. This paper has an assessment on the various scheme of OFDM's Frequency offset scheme.

ACKNOWLEDGEMENT

This paper would not have been possible without my guide Prof. Nitin Lonbale from Institute of Research and Technology, Bhopal. I wish to express my thanks to all the people who helped turn the World-Wide Web into the useful and popular distributed hypertext. I also wish to express thanks the anonymous reviewers for their valuable suggestions.

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