

Estimate Transient Carrier Frequency offset by using Low Complexity Parametric Estimation Algorithm

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Abstract:- In this paper we are presenting the carrier frequency offset, the primitive objective of this Paper is to estimate transient carrier frequency offset by using low complexity parametric estimation algorithm. We explore the modeling and estimation of the transient CFO, which is modeled as the response of an under damped second order system. To compensate for the transient CFO, we propose a low complexity parametric estimation algorithm, so in the proposed method we are estimated the CFO by using frequency domain in this method the signal is travelled in parallel so more signals can be send through this method.

Key Words- carrier frequency offset, time division duplex (TDD), orthogonal frequency division multiplexing (OFDM)

1. INTRODUCTION

Optimizing wireless physical layer for capacity and reliability has led to many improvements from air interface design to signal processing techniques that mitigate radio frequency impairments. Validating these improvements in wireless testbeds has become an important step in fine-tuning the algorithms and identifying any unforeseen modeling errors. For example, the carrier frequency offset (CFO) is well understood radio frequency (RF) impairment in wireless systems [1]. While experimentally validating the CFO estimators in our wireless testbed, we observed an unexpected CFO behavior in time division duplexing (TDD) operation, i.e., a transient CFO waveform caused by the switching between TX and RX in RF front-end hardware. The impact of the transient CFO can be more pronounced in wireless systems where time division duplex (TDD) is deployed as the

duplexing scheme. It must be taken into account in applications such as remote robotics, wireless automation, and mobile gaming where extremely low latency and reliability requirements have to be met over connections with future 5G or legacy wireless systems. Such systems include the next generation mobile communication systems, Long-term Evolution (LTE) with TDD mode [2]–[4], and cooperative communications where TDD mode is operated in cooperative relay transmissions [5][6]. For instance, TDD LTE is designed with guard period between the switching from the downlink to the uplink. However, the purpose of the guard period is to guarantee that user equipment (UE) can switch between reception and transmission with no overlap of signals, instead of dealing with the transient effect. In addition, the length of the guard period is designed to handle the propagation delay in the cells. Thus, the hardware design is more challenging for UE away

from the base station due to the shorter switch time allowed.

OFDM system is sensitive to carrier frequency offset estimation (CFO), which leads to degrade the system performance. The CFO is the mismatch of the transceiver oscillators or the Doppler Effect. The CFOs lead to both inter-carrier interference and multiple-access interference, which could severely degrade the system performance. Previously the CFO estimation scheme for OFDMA uplink transmissions has intensively been investigated like by using frequency domain pilot system, Using ML algorithm, but those methods are complex. In this paper we are estimating carrier frequency offset estimation for multiuser uplink and also we are estimating channel estimation in fading conditions. CFO estimation is same as in the paper [1] with just changes we are estimating by using same estimators. The CFO estimated by using Fusco's estimator as the first estimator and the proposed method is the second estimator. In paper [2] considered the problem of data-aided joint symbol timing and carrier frequency offset estimation for filter bank based multicarrier systems. In that they provided new joint symbol timing and CFO synchronization algorithm exploiting the transmission of a training sequence. In the CFO estimation in the uplink of an OFDMA system, the base station (BS) needs to estimate multiple CFO's from multiple users. The choice of CFO estimation methods in the BS is closely related to the adopted subcarrier allocation scheme [3].

The main aim of this paper is to propose a low-complexity data-aided CFO estimation for OFDM with block allocation scheme. And also we are estimating the iterative channel estimation by using LS (Least square) channel estimation and MMSE (Minimum mean square) channel estimation which is present in paper [4].

2. SYSTEM MODEL

A. The Traditional CFO Estimation

We assume that the receiver estimates the CFO through the preamble OFDM symbol, who's first and second halves are identical. Then, we can express the transmitted preamble signal as [24]

$$s(t) = \begin{cases} s_1(t) & 0 \leq t \leq T \\ s_1(t - T) & T \leq t \leq 2T \end{cases} \quad (1)$$

Where T is the time interval between the two halves. Thus, the received signal impaired by CFO can be written as the received signal from base station is given by

$$r[n] = y[n] + v[n] = \sum_{p=0}^{P-1} y_p[n] + v[n] \quad (1)$$

Where, $v[n]$ is an AWGN with variance σ_v^2 and $y_p[n]$ is the received signal from the p th user as

$$y_p[n] = (x_p[n] * c_p[n]) e^{j2\pi\epsilon_p n/N}, \quad (2)$$

Where, $x_p[n]$ is the transmitted signal from p th user, and $c_p[n]$ is the channel response between the p th user and base station. It is assumed that $c_p[n]$ is non-zero only for $n = 0, 1, \dots, N_c - 1$, where N_c is the channel delay spread and ϵ_p is the normalized CFO of the p th user, $P = 0, 1, \dots, P - 1$.

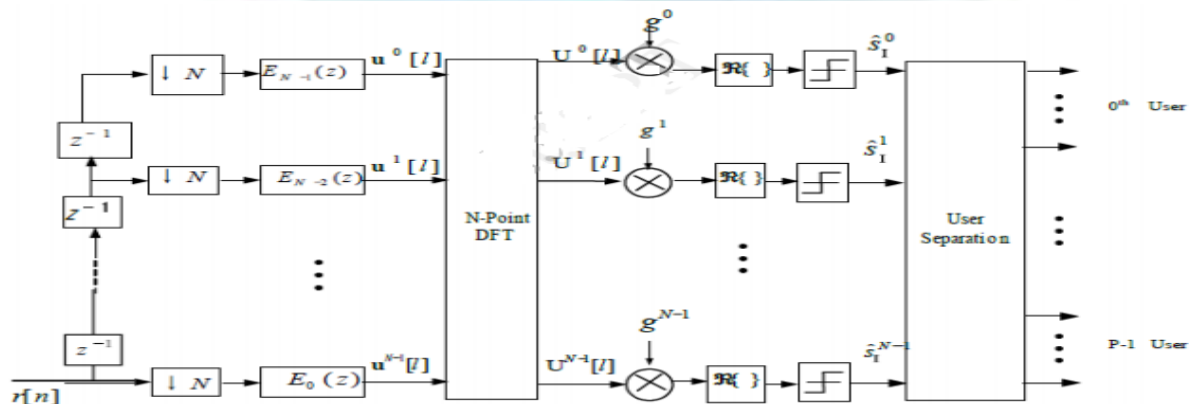


Fig.1. This is in-phase receiver part of OFDM

Experimental Characterization of CFO:

The traditional CFO estimation algorithm presented above has been implemented on the test bed that we have set up using two terminals. Each terminal combines National Instruments (NI) FlexRIO family modules and the Ettus USRP RF front-ends [25]. The terminals are configured as a master or a slave to operate in TDD mode for comprehensive real-time wireless experiments. We use orthogonal frequency division multiplexing (OFDM) as the modulation technique for our physical layer design. The time division duplexing (TDD) is operated with a frame structure defined. The master terminal transmits the preamble OFDM symbol in the beginning of each frame, followed by four regular OFDM symbols. Correspondingly, after TX to RX switching, the slave terminal receives the preamble and four regular OFDM symbols consecutively. The slave terminal updates time and frequency synchronization through the preamble symbol. Table I lists the OFDM system parameters. We compare the estimated CFO and the expected CFO on our test bed running in TDD mode. Using a common reference for both the master and slave terminals, we expect the average CFO estimation in to be 0 Hz. However, we observe quite surprising results from this experiment. The traditional CFO estimator has a bias of 1000 Hz over the preamble OFDM symbol contrary to the anticipated 0 Hz CFO. The estimated CFO by the traditional CFO estimator decays with time. The output of the traditional CFO estimator reduces to 65 Hz in the second OFDM symbol and even reduces to less than 10 Hz in the fourth and fifth OFDM symbols. The estimated CFOs of the second to the fifth OFDM symbols are obtained by computing the phase shift between the received cyclic prefix (CP) and the end part of the OFDM symbol [15]. Interestingly, similar phenomenon has been observed and extensively analyzed on Rice University WARP radios [1]. As observed and extensively documented in [1], this phenomenon can occur in compact and highly integrated RF transceivers that share a common power supply

across the transmission and receive functions. The power supply distribution diagram of the RF front- ends in our testbed. When TX to RX or RX to TX switching occurs, the load current changes. As a result, the supply voltage of the voltage controlled oscillator (VCO) and the phase-locked loop (PLL) in the RF transceiver varies correspondingly. The power supply voltage of the VCO&PLL is probed to verify that the carrier frequency is going through a drastic change during RF switching, the transient CFO seriously distorts the phase of the received signal of the preamble OFDM symbol.

3. CFO Estimation

The Proposed Estimator In a time-domain CFO estimation algorithm using periodical training sequences was proposed for single user OFDM systems. This may not be extended to multiuser case, where signals from P users have been received with different CFO's at BS which cannot be easily separated in the time domain. To overcome this problem, we taken a frequency-domain CFO estimator for OFDM using periodical training sequences. To reduce this computational complexity of the estimator, used only real training sequences such that the estimator only uses the in-phase parts. in this the filter values taken as non-zero values i.e., $-N \leq n \leq N$. The transmitted training signal $x_p[n]$ satisfies the following condition approximately,

$$x_p[n + N] \approx x_p[n] \quad , \quad n = N_1, \dots, N_1 + \beta N - 1$$

Where N_1 is the transient in the time domain. By calling (2), we have two $\beta N \times 1$ successive overlapped signal vector from the Pth user called $Y_{p,1}$ and $Y_{p,2}$ such that

$$Y_{p,2} = e^{j2\pi\epsilon_p} y_{p,1}, \quad p = 0, 1, \dots, P - 1$$

According $N \times 1$ vectors u_1 and u_2 are the received vectors at the input of DFT block due to r_1 and r_2 respectively as

$$\left\{ \begin{array}{l} u_1 = \sum_{p=0}^{P-1} \sum_{i=1}^{\beta} y_{p,1}[l + i] \odot h[\beta - i] + w_1 \\ u_2 = \sum_{p=0}^{P-1} \sum_{i=1}^{\beta} e^{j2\pi\epsilon_p} y_{p,1}[l + i] \odot h[\beta - i] + w_2 \end{array} \right\}$$

If we put some subcarriers as a guard between each pair of adjacent user bands for multiuser case, the overlapping between adjacent users may be neglected. The CFO estimation may be

performed after DFT. The CFO estimated separately for OFDM in

$$\hat{\epsilon}_p = \frac{1}{2\pi} \left(\sum_{k \in S_p} U_1^{k*} U_2^k \right)$$

4. CHANNEL ESTIMATION

The channel estimation techniques are used for estimating the channel response at the reference symbols. Linear Interpolation is used to determine the channel at data symbols [6]. A.LS channel estimation: LS (Least Square) channel estimation is the simplest channel estimation method. LS channel estimation is the channel estimator from least squares. Loop impulse response using the LS estimate allows $(Y - XH)^H(Y - XH)$ minimum, obtained by calculating

$$\hat{h}_{LS} = X^{-1}Y \quad (14)$$

Gaussian white noise and ICI have large impact on LS algorithm, so the accuracy of the algorithm, so the accuracy of the algorithm is limited [6]. Even though the performance of LS estimation is not perfect, but its implementation complexity is very low in certain error conditions, therefore LS is widely used.

MMSE Estimation: Because the accuracy based on LS criterion is not high, in order to improve the accuracy of estimation algorithm, the

estimation based on the MMSE (minimum mean square error) criterion is used to improve accuracy with the information of channel estimation. The algorithm in the frequency domain is defined as the formula:

$$\hat{h}_{MMSE} = R_{HH} R_{YY}^{-1} Y$$

Where,

$$R_{HY} = R_{HH} X^H$$

$$R_{YY} = X R_{HH} X^H + \sigma_n^2 I_N$$

σ_n^2 is the variance of additive Gaussian noise, $R_{HH} = E[H H^H]$ is the autocorrelation matrix about channel response [6]. Therefore, the estimation algorithm based on channel response MMSE in frequency domain can be expressed as the formula

$$\hat{h}_{MMSE} = R_{HH} (R_{HH} + \sigma_n^2 (X X^H)^{-1})^{-1} \hat{h}_{LS}$$

The structure of MMSE estimator is more complicated than LS, but it is superior to LS algorithm on SNR.

5. RESULTS

In this paper we considered as $N = 256$ and number of users is $P=4$. So total number of subcarriers is 64. The channel delay 0, 0.31, 0.71, 0.09, 1.73 and 2.51 microseconds [1]. The value of ϵ is in between $[-0.5 - 0.5]$. The MSE of the proposed estimator

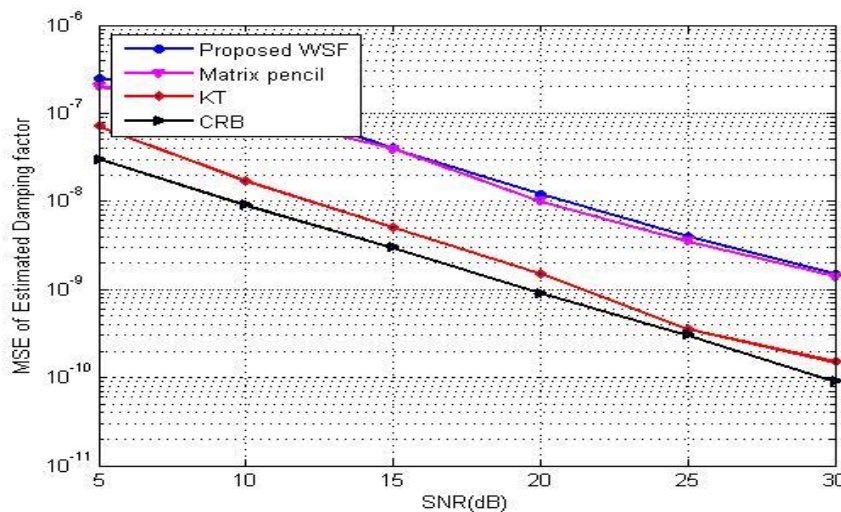


Fig 2. MSE of proposed estimators

In the above Fig.3. Shows that the Bit Error Rate for both estimators, for different values. We see

that the BER of the proposed estimator has the better performance than the other estimator.

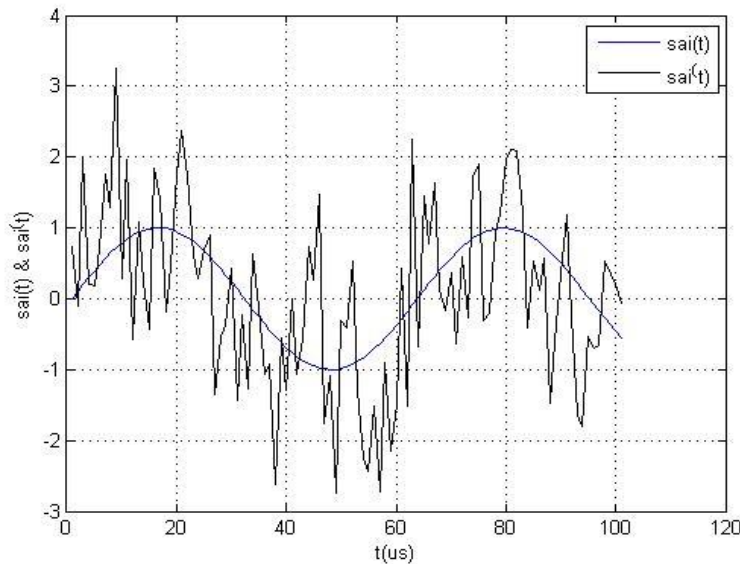


Fig 3.The OFDM Signal

The Fig.2 &Fig.3 shows the performance of the MSE estimation scheme. The simulation result shows that through the proposed iterative channel estimation method, dramatic performance.

5. CONCLUSIONS

In this paper we explored the modeling and estimation of the transient CFO, which is modeled as the response of an under damped second order system. To compensate for the transient CFO, we propose a low complexity parametric estimation algorithm, so in the proposed method we are estimated the CFO by using frequency domain thus the signal is travelled in parallel so more signals can be send through this method.

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