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Carrier Frequency Offset Estimation For Orthogonal Frequency Division Multiplexing (OFDM)

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Abstract : This paper addresses the problem of estimating and compensating the residual CFO at receiver employing OFDM system .the performance of OFDM system is sensitive to CFO, which gives rise to the ICI.some implementation aspects of the estimator are discussed as Cyclic Prefix, Training symbol with fixed and variable pilot power. The modulation used for the estimation techniques are Quadrature Amplitude Modulation (QAM). The simulation results verify theoretical analysis.

Keywords: Additive White Gaussian Noise (AWGN) ,Cyclic prefix (CP), Carrier Frequency Offset (CFO),Signal to noise ratio (SNR),Training Based (TB).

1.INTRODUCTION

OFDM is a frequency-division multiplexing (FDM) scheme used as a digital multi-carrier modulation method Each sub-carrier is modulated with a conventional modulation scheme as quadrature amplitude modulation at a low symbol rate,maintaining total data rates similarto conventional single carrier modulation schemes in the same bandwidth.Theorthogonality also allow high spectral efficiency,with a total symbol rate near the Nyquist rate for the equivalentbaseband signal (i.e. near half the Nyquist rate for the double-side band physical passband signal). Almost the whole available frequency band can be utilized. OFDM generally has a nearly 'white' spectrum, giving it benign electromagnetic interference properties with respect to other co-channel users.In this paper the CFO estimation is performed at the random residual cfo at the receiver. The estimations used are cyclic prefix (CP) and training sequence with fixed and variable pilot power. cyclic prefix serves two purposes.As a guard interval, it eliminates the intersymbol interference from the previous symbol.As a repetition of the end of the symbol, it allows the linear convolution of a frequency-selective multipath channel to be modelled as circular convolution, which in turn may be transformed to the frequency domain using a discrete Fourier transform. This approach allows for simple frequency-domain processing, such as channel estimation and equalization. The main purpose of training sequences is to estimate channel coefficients of individual subcarriers, not synchronization. Pilot tones are specific sub-carriers that are chosen ahead of time. They carry a specific repeating pattern. They are used for channel estimation and additionally can be used for fine synchronization.

The rest of paper is organized as follows:literature review is given in section 2, proposed system in section 3, OFDM system model is given in section 4, CFO estimation methods in section 5,spectral efficiency results shown in section 6, simulation results shown in section 7,and conclusion in section 8

2.LITERATURE REVIEW

In the Existing system the performance analysis of orthogonal frequency division multiplexing with residual carrier frequency offset uses the binary phase shift keying for the modulation and rayleigh channel is used .While the use of Bpsk modulation the per

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symbol used will be low and its modulation depend only on the phase.Thecyclic prefix method used for the cfo estimation but without the use additional pilots.then the estimation error increases.

3.PROPOSED SYSTEM

In the proposed method the performance of OFDM can be analysed by the Quadrature amplitude modulation and the Additive White Gaussian Noise channel is used.TheQAM modulation depends on both the phase and the amplitudeof the signal.Cyclic prefix and training based methods are used the estimation CFO.

4. SYSTEM MODEL

The baseband OFDM signal can be written as

$$s(t) = \frac{1}{\sqrt{N}}\sum_{n=0}^{N-1} a_n e^{j2\pi\frac{n}{T}t}\left[-T_{G,}T\right] \quad (1)$$

Where N is the number of sub-carriers, TG is the length of the cyclic prefix (CP), and T is the length of the OFDM symbol duration. Here T = N/R and R is the symbol rate of the input data .

The channel impulse response of the Rayleigh fading channel is

$$h(t) = \sum_{l=0}^{L-1} gl\delta(t - tl)\mathbf{(2)}$$

Where gl and _l are the complex amplitude and propagation delay .

Therefore,for time synchronization and a residual CFO of Δ, the received signal of the cyclic prefix is

$$\mathrm{r(t)} = \frac{1}{\sqrt{\mathrm{N}}}\mathrm{e}^{\mathrm{j}2\pi\frac{\Delta}{\mathrm{T}}}\sum_{\mathrm{l}=0}^{\mathrm{l}-1}\mathrm{gl} \quad (3)$$

Where is the complex additive white Gaussian noise (AWGN) with zero mean. The N-point FFT samples at the receiver are

$$\mathrm{Y}=\frac{1}{N}\sum_{K=0}^{K-1} gla_n \quad (4)$$

Where wpis a zero mean complex Gaussian RV with variance N0.

5.CFO estimation:

A. Cyclic Prefix Based:when the cyclic prefix is used for CFO estimation, the CFO estimator variance is given as

$$\sigma_{\Delta=}^{2}\frac{1}{\pi^2 T_G SNR_E} \quad (5)$$

where SNRE is the signal-to-noise ratio during the estimation phase.

when the residual CFO is distributed as Δ ∼ N(0, σ_Δ^2) the overallaverage mutual information over the pth sub-carrier can be approximated by

$$R_{P\approx}\left(\frac{SNR_D+1}{SNR_D\frac{\pi^3}{3}\sigma_\Delta^{2+1}}\right) \quad (6)$$

In the CP-based (CB) CFO estimation, we have

$$R_P \approx \log_2\left(\frac{\frac{N}{N+T_G}SNR+1}{\frac{N}{3T_G}N+T_G+1}\right) \quad (7)$$

4 that the higher the number of sub-carriers N and SNR.

B.TrainingSequence Based: Training sequence is used for CFO estimation, the CFO estimator , and K is the number of identical parts in the training sequence.when the residual CFO is distributed as Δ ∼ N(0, $\sigma_\Delta^{2)}$, the overallaverage mutual information over the pth sub-carrier can be approximated by

$$R_P \approx \log_2\left(\frac{SNR_D+1}{SNR_D\frac{\pi^2}{3}\sigma_\Delta^2+1}\right) \quad (9)$$

Training based (TB) CFO estimation with pilot

and signal power,

$$R_P \approx \log_2\left(\frac{\frac{N}{N+T_G+T_E}SNR+1}{\frac{2}{3(N+T_G+T_E)}+1}\right) \quad (10)$$

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Training based (TB) CFO estimation, with equal pilot power.

6.SPECTRAL EFFICIENCY

Spectral efficiency is the average number of information bits which can be transmitted with an arbitrary small error probability per unit time per unit Hertz. Christo Ananth et al. [4] discussed about Improved Particle Swarm Optimization. The fuzzy filter based on particle swarm optimization is used to remove the high density image impulse noise, which occur during the transmission, data acquisition and processing. The proposed system has a fuzzy filter which has the parallel fuzzy inference mechanism, fuzzy mean process, and a fuzzy composition process. In particular, by using no-reference Q metric, the particle swarm optimization learning is sufficient to optimize the parameter necessitated by the particle swarm optimization based fuzzy filter, therefore the proposed fuzzy filter can cope with particle situation where the assumption of existence of "ground-truth" reference does not hold. The merging of the particle swarm optimization with the fuzzy filter helps to build an auto tuning mechanism for the fuzzy filter without any prior knowledge regarding the noise and the true image. Thus the reference measures are not need for removing the noise and in restoring the image. The final output image (Restored image) confirm that the fuzzy filter based on particle swarm optimization attain the excellent quality of restored images in term of peak signal-to-noise ratio, mean absolute error and mean square error even when the noise rate is above 0.5 and without having any reference measures.The system resource bandwidth and power are wasted by substituting the cyclic prefix and training sequences thus it also used to estimate and compensate for the CFO.The spectral efficiency of OFDM systems for a given CFO is

$$G(\Delta) = \frac{1-\alpha}{N+T_G} \qquad (11)$$

where α is the time resources allocated to CFO, Rp is the conditional average for the mutual information over the pth sub-carrier for a given**Δ.**

$$R_P(\Delta) = \log_2(1 + SNR_P)\} \qquad (12)$$

The main aim is to find the average spectral efficiency and SNR of the signal.

7.SIMULATION RESULTS

CFO Estimation is done by using two different techniques , first one is the cyclic prefix with the estimation of phase. Second , is the training sequences with pilot power.

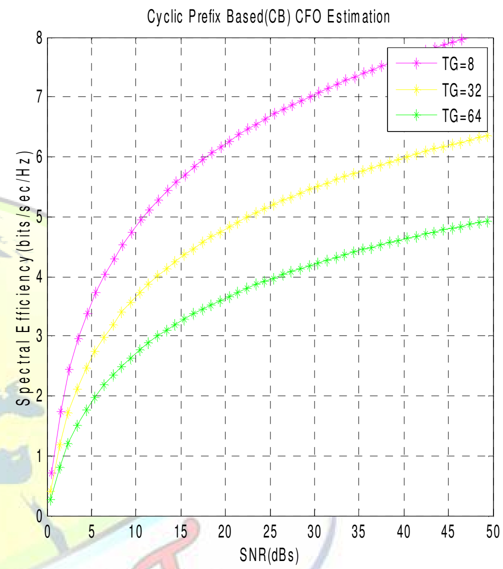

Fig. 1. Spectral efficiency versusSNR for the cyclic prefix based (CB) CFO estimation with SNRE = SNR.

In Fig. 1, shows the spectral efficiency versus SNR is drawn when equation (5) is used as the variance for the CP-based CFO estimation . without the use of training sequence in CFO estimation, ν = 0 , α = 0 and TE = 0. As the length of cyclic prefix TG increase then the number of subcarriers also increases .Meanwhile as TG increases then the CFO estimation error decreases.

In Fig. 2, spectral efficiency versus SNR is drawn when equation (8) is used as a variance for the training based CFO estimation. The taining based estimation method used the equal pilot power. OFDM block is divided into two block, one OFDM block is used fot the CFO estimationand the another block is used for assuming the coherence time.As the length training sequence TE increases with the increase in the spectral efficiencyof the signal.

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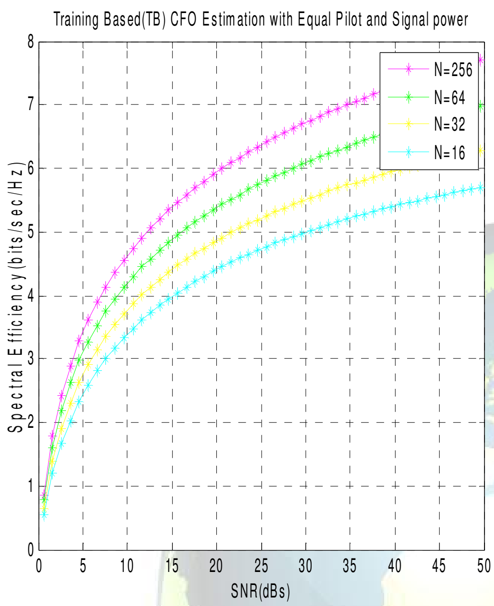
Fig. 2. Spectral efficiency versus SNR for the training based (TB) CFO estimation with equal pilot power, α = 1/9, TG = 8 and σ = 1.



The graph shows the increase in spectral efficiency versus the SNR with number of sub- carriers, N is both, the cyclic prefix based (CB) CFO estimation, and the training based (TB) CFO estimation.Inspite of this the accuracy also increased with the increase in signal to noise ratio of the signal in the carrier frequency offset estimation techniques.

It is justified that increasing SNR decreases the ICI in CFO estimation.

8.CONCLUSION

In this paper ,the performance analysis of OFDM system with random residual cfo is studied. The simulation results show the good performance of our proposed scheme of QAM in AWGN Channel.CFOestimation performance is superior then compare to cyclic prefix based and Training sequence based pilot power. By using these two techniques the CFO has been estimated and thus the spectral efficiency also improved.

Further intensive research is needed with Transmit diversity and imperfect channel estimation in OFDM system.

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