CFO & PAPR Estimation for OFDM/OQAM Systems Based on Sub Channel Signals

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Abstract— In this paper is to consider the problem of carrier-frequency offset (CFO) estimation and PAPR for orthogonal frequency-division multiplexing (OFDM) systems and offset quadrature amplitude modulation (OQAM). a new method for CFO synchronization and PAPR estimation has been proposed by exploiting the approximate CSP of the beginning of a burst of OFDM/OQAM symbols due to the presence of the time offset. Performance analysis with reference to the considered OFDM/OQAM system shows that the proposed CFO and PAPR achieve acceptable performance for realistic values of Eb/N0. We considered OFDM/OQAM system with non-ideal receivers and imperfect CSI. While a comparative robustness to CFO was widely anticipated, the OFDM/OQAM system is shown to be more sensitive to IQI effects. A joint estimation algorithm is used to alleviate the IQI/CFO Distortion and obtain reliable channel estimates for the coherent reception.

I. INTRODUCTION

Technology and system requirements in the telecommunications field are changing very fast. Over the prior years, considering that the transition from analog to digital communications, and from wired to wireless, different standards and solutions have now been adopted, developed, implemented and modified, often to cope with new and different business requirements. Today, more and more, telecommunication network operators struggle to offer new advanced services in a stylish and functional way [2].]. In a radio communication system, there are numerous paths for a sign to feed from the transmitter to a receiver. Sometimes there is a direct path where in actuality the signal travels without being obstructed, which is called a Line Of Sight (LOS)path. Generally, aspects of the signal are refracted by different atmospheric layers or reflected by the bottom and objects involving the transmitter and the receiver such as for example vehicles, buildings, and hills, which is called Non Line Of Sight (NLOS) paths. These components travel in various paths of different length and combine at the receiver. Thus, signals on each path suffer different transmission delays and attenuation because of the finite propagation velocity. The combination of the signals at the receiver results in a destructive or constructive interference, depending on the relative delays involved.

II. OVERVIEW OF OFDM SYSTEM

As wireless communication evolves towards broadband systems to support high data rate applications, we need a technology that may efficiently handle frequency selective fading. The Orthogonal Frequency Division Multiplexing (OFDM) system is widely found in this context. The main element notion of OFDM would be to divide the whole transmission band into several parallel sub channels (also called subcarriers) so that each sub channel is just a flat fading channel [11]-[13]. In cases like this, channel equalization can be performed in most sub channels in parallel using simple one-tap equalizers, which may have really small computational complexity. A block diagram of an OFDM system is depicted in fig.1.Here, for simplicity and clearness of illustration, channel coding block is left out. The incoming digital data are first passed to a serial to parallel converter (S/P) and changed into blocks of N data symbols. Each block is called a frequency-domain OFDM symbol and N is the number of sub channels.

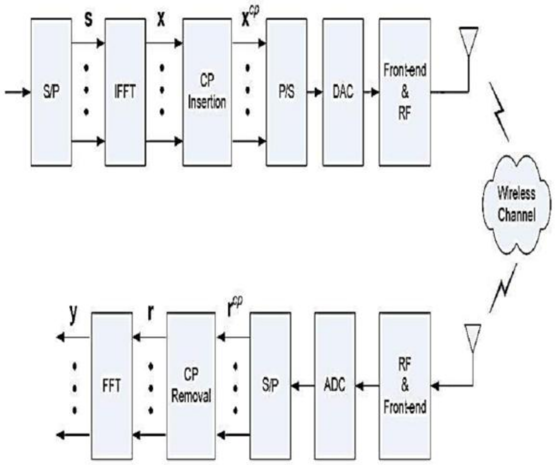

Figure 1 Block diagram of an OFDM system

By combining OFDM with error control coding, the coded OFDM system can also be better made to narrow band interferences [11]. This is because narrow band interferences only affects a small number of subcarriers and causes detection errors on these subcarriers. These detection errors can usually be corrected by error control coding. Due to these advantages, OFDM has been adopted in lots of modern wireless communication standards such as IEEE 802.11a/g WLAN, IEEE 802.16e Broadband Wireless Access (also known as WiMAX), Digital Audio Broadcasting (DAB) and Digital Video Broadcasting (DVB).

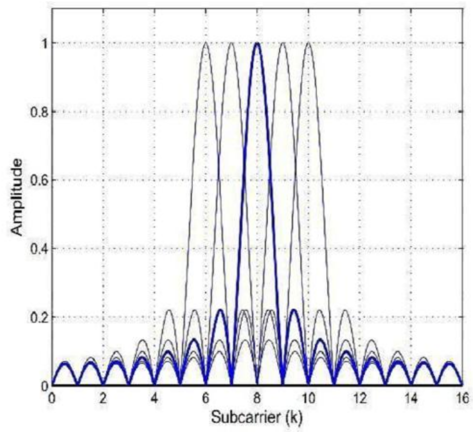

Figure 2 Amplitude spectra of subcarriers 6 to 10 for an OFDM system with 16 subcarriers

However, OFDM also has some disadvantages. Firstly, because the modulation is performed using IDFT, the peak to average power ratio (PAPR) of time domain OFDM signals is higher compared to single carrier systems. This puts high requirements on the dynamic range of the RF amplifiers and introduces extra clipping noise in the system [12], [13]. Another disadvantage of the OFDM system is that it is more sensitive to frequency synchronization 1errors compared to single carrier systems.

Effects of frequency synchronization errors in OFDM system

In the earlier section, an breakdown of OFDM systems is presented. Features of OFDM were highlighted and plus it is found that sensitivity to frequency synchronization errors in the shape of carrier frequency offset (CFO), is really a key disadvantage of OFDM systems. In this section, a more descriptive study on the results of CFO on the performance of OFDM systems is presented. While the name suggests, CFO is definitely an offset between the carrier frequency of the transmitted signal and the carrier frequency used at the receiver for demodulation. In wireless communications, CFO comes mainly from two sources:

• The mismatch between oscillating frequencies of the transmitter and the receiver local oscillators (LO).

• The Doppler effect of the channel due to relative movement between the transmitter and the receiver.

At the receiver, the effect of CFO is mitigated through frequency synchronization. Fig.3 shows an OFDM receiver with frequency synchronization implemented in both the analog and the digital domains. The received signal from the receive antenna is first passed to the receiver front-end. Here, to make sure that the local oscillator at the receiver front-end is operating with sufficient accuracy, its reference frequency is continuously adjusted by the analog coarse frequency synchronization unit [13], which is made

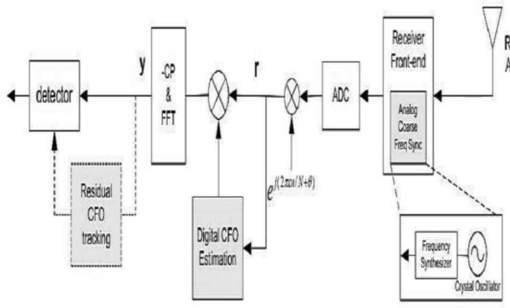

Figure 3 An OFDM receiver with frequency synchronization up of crystal oscillator and a volume synthesizer.

This CFO introduces a time dependent phase rotation to the received digital time-domain signal, where n is the time index, and N is the number of subcarriers. Together with a constant phase offset due to the channel and the analog processing, this introduces a phase rotation of as shown in fig.2.2.1. In this way, we can write the received time-domain signal in the mth OFDM symbol interval in the following form [16]

$$\mathbf{r}^m = \mathbf{EWH}^m \mathbf{s}^m e^{j(2\pi\varepsilon(m-1)\left(1+\frac{N_g}{N}\right)+\theta)} + \mathbf{n}^m. \quad (2.2.1)$$

$$\mathbf{E} = \mathrm{diag}(1, e^{\frac{j2\pi\varepsilon}{N}}, \dots\dots.. e^{j2(N-1)\varepsilon/N})$$
$$e^{j(2\pi\varepsilon(m-1)\left(1+\frac{N_g}{N}\right))}$$

The CFO matrix is a diagonal matrix containing the CFO value ϵ, and N is the number of subcarriers. Matrix W is the NXN IDFT matrix, H^m is a channel frequency response for different subcarriers, $s^m$is the transmitted signal for them the OFDM symbol and n^m is the AWGN noise vector. Here we split the phase rotation causedby the CFO into the CFO matrix and a phase offset for OFDM symbol m.

III. ANALYSIS OF INTER-CARRIER INTERFERENCE

OFDM is an excellent technique to manage impairments of wireless communication channels such as for instance multipath propagation. Hence, OFDM is an operating candidate for future 4Gwireless communications techniques [1]-[4]. On one other hand, one of numerous major drawbacks of the OFDM communication system could be the drift in reference carrier. The offset within received carrier will miss orthogonality on the list of carriers. Hence, the CFO causes adiminished number of desired signal amplitude in the output decision variable and introduces ICI.Then it raises a rise of BER. The result attributable to CFO for OFDM system was analyzed in[7]-[9]. In [7] BER upper bound of OFDM system is analyzed without ICI self-cancellation and BER of OFDM system is analyzed using self-cancellation, but this technique is less accurate. In[9], it's indicated that CFO must certanly be less than 2% of the bandwidth of the sub channel to guarantee the signal to interference ratio to be greater than 30 db.

Doppler shift due to relative motion involving the transmitter and receiver, or bydifferences involving the frequencies of the neighborhood oscillators at the transmitter andreceiver.In this thesis, the frequency offset is modeled as a multiplicative factor introduced in thechannel, as shown in fig.4.

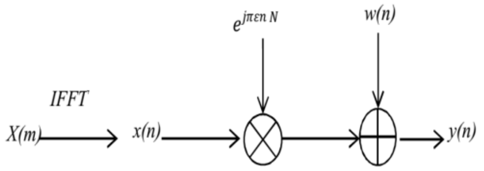

Figure 4 Frequency Offset Model. The received signal is given by,

$$y(n) = x(n)\exp\left(\frac{j2\pi n\varepsilon}{N}\right) + w(n)$$

Where is the normalized frequency offset, and is given by $\Delta f N T_s$, Δf is the frequency difference between the transmitted and received carrier frequencies and Tsis the subcarrier symbol period. w(n) is the AWGN introduced in the channel.

IV. SIMULATION RESULTS

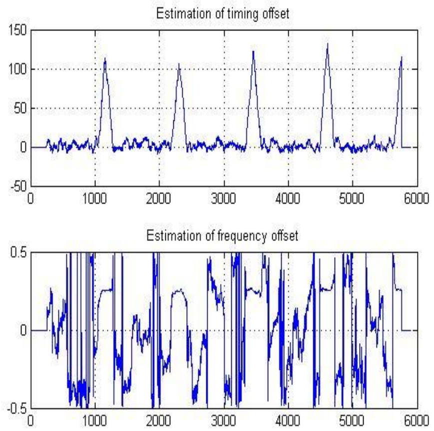

Fig5 timing offset performance

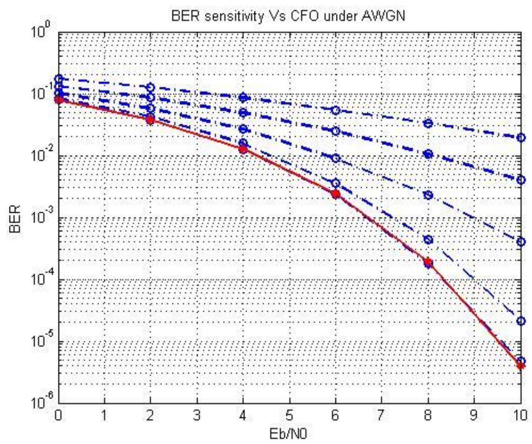

Fig6 BER sensitivity Vs CFO Under AWGN

Figure5 shows that in both multipath channels E_b/N_0 12 dB (in AWGN channel Eb/N0 7 dB) is needed to achieve an RMSE equal to10%, which is determined in [20] as a tolerable input RMSE for successful frequency-domain pilot based residual CFO compensation, while E_b/N_0 18dB is needed to achieve (except for method B) on both multipath channels an RMSE of2%. Among the different methods here proposed, we can notice that in multipath channels and for E_b/N_0 larger than 11dB, method A is superior to method B and they are practically equivalent otherwise; moreover, only for Eb/N0smaller than14dB, the additional complexity needed for applying method C is justified by the performance improvements. In AWGN channel, instead, method B is superior to method A for E_b/N_0 smaller than14dB and they are practically equivalent otherwise; consequently, the method C provides the best performance.

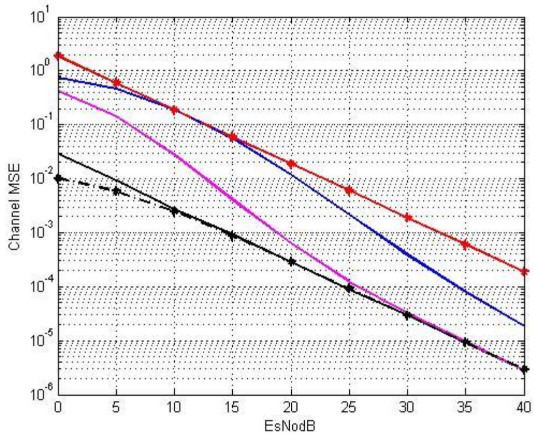

Fig 7 RMSE of the proposed ST estimators

The noise effect on the statistics can have a significant impact since it may lead to single out a position that is not correct. In such a case, there is no guarantee that the error remains small because any time step of the observed interval may be selected. In order to reduce the effects of such outliers on the overall performance, we set a threshold Σ and we utilize the algorithm for timing estimation only when the statistics is larger than Σ; otherwise, we provide as output of the overall timing estimator the coarse estimate obtained by using.

V. CONCLUSION

The problem of blind synchronization for OFDM/OQAM systems has been considered. Specifically, a new method for blind ST and CFO synchronization has been proposed by exploiting the approximate CSP of the beginning of a burst of OFDM/OQAM symbols due to the presence of the time offset. The results of the performance analysis with reference to the considered OFDM/OQAM system show that the proposed blind ST and CFO estimators, complemented by a simpler coarse ST estimator, achieve acceptable performance for realistic values of *Eb/N*0. We considered OFDM/OQAM system with non-ideal receivers and imperfect CSI. While a comparative robustness to CFO was widely anticipated, the OFDM/OQAM system is shown to be more sensitive to IQI effects. Degradation suffered as a consequence of the imperfect receiver processing was quantified in terms of the SINR loss. To alleviate the IQI/CFO Distortion and obtain reliable channel estimates for the coherent reception, a joint estimation algorithm was discussed. We found that with the compensation scheme in place and in a quasi-static Rayleigh-fading scenario, the presence of IQI and CFO incurs at most 1 dB loss in the error performance.

FUTURE SCOPE

The following are the some of the interesting extensions of the present work:

1).An interesting topic for future research is to perform more extensive performancecomparisons between FFT based OFDM, DHT based OFDM, and DCT based OFDMsystems under additional real-world channel impairments, such as multipath fading,time dispersion which leads to inter symbol interference (ISI).

2) The main problems with OFDM signal is very sensitive to carrier frequency offset,and its high Peak to Average Power Ratio (PAPR). So, these three transform basedOFDM systems can be tested for these problems.

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