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SIGNAL PROCESSING IN MIMO-FBMC SYSTEM

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***Abstract:*The requirements of the next generation communication system motivate analysis in advanced Multicarrier Modulation (MCM) schemes such as filter bank-based multicarrier (FBMC) modulation. This project focuses on the offset quadrature amplitude modulation based FBMC, called as FBMC/OQAM which gives an outstanding spectral efficiency and confinement in an exceedingly variety of channels and applications. The possibility to have independent (non-overlapping) sub-channels is the key characteristic of FBMC. As a multicarrier scheme, FBMC can benefit from multi-antenna systems and therefore MIMO technique is applied. The Multiple Input Multiple Output (MIMO) technique is expected to play a major role in the future communication systems creating new research problems and calling for new ideas and methods that are adapted to the particularities of MIMO-FBMC/OQAM system. The goal of this project is to focus on the signal processing problems and provide a concise yet comprehensive summary of the recent advances in the MIMO-FBMC/OQAM system.**

KEY WORDS: Multicarrier modulation, FBMC, MIMO, OQAM, Precoding techniques.

I.INTRODUCTION

Wireless communication is defined as the transfer of information or power between two or more points that are not connected by an electrical conductor. The most common wireless technologies use radio. Distances can be short with radio waves, such as a few meters for television or as far as thousands or even millions of kilometers for deep-space radio communications. The term wireless has been used twice with slightly different meaning in the history of communications. The term "wireless" came into public use to refer to a radio receiver or transceiver (a dual purpose receiver and transmitter device), establishing its application in the field of wireless telegraphy early on; now the term is used to describe cellular networks and wireless broadband Internet of modern wireless connections. It is also used in a general sense to refer to any operation that is implemented without the use of wires, such as "wireless remote control" or "wireless energy transfer", regardless of the specific technology.

One of the best-known examples of wireless technology is the cellular phone, also known as a mobile phone. The radio waves from signal-transmission towers are made use by these wireless phones to enable their users to make phone calls from many locations worldwide. They can be used within the range of the mobile telephone site used to accommodate the equipment required to transmit and receive the radio signals from these instruments. An essential component of mobile computing is Wireless data communications are. The various available technologies differ in coverage range, local availability, and performance, and in some circumstances, the mobile users must be able to employ multiple connection types and switch between them.

An explosive growth of Internet access is fueled by the ever increasing demands for digitalized anywhere and anytime contents. With the rapid increase of applications that are data hungry, it is expected that in the next few years there will be a tremendous increase in the number of devices with Internet connection, leading to a wireless connectivity among users and machines. The unprecedented traffic increase in human and machine type communications poses stringent constraints in throughput, delay and energy. Methods that are being considered to respond to these demands with the prevailing spectrum scarcity include: authorized spectrum sharing, cell densification, millimeter wave (mm-wave) communications and large scale antenna arrays at the base station. It is expected that the 5th generation (5G) systems will support the future requirements through the combination of the above strategies. Hence, 5G is envisioned to unleash the potential of multiple-input multiple-output (MIMO) technology and to provide spectrum flexibility.

This shows that the 5g requirements will be fulfilled by the waveform type and the MIMO solution to be adopted. An air interface which is well suited and helps in achieving fine spectrum control is bound to be adopted in the upcoming 5G standard. The Orthogonal

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Frequency Division Multiplexing(OFDM) is a dominant transmission technology that is used now a days.The robustness against the multipath fading and the ease of its implementation is the beauty of OFDM stems, which leads to modeling the end-to-end communication system as a set of parallel frequency flat sub channels. These reasons explain why OFDM has been the modulation of preference in most of the current wireless communication standards such as: Long-Term Evolution (LTE) Worldwide Interoperability for Microwave Access (WiMAX) wireless local area networks (WLAN) digital video broadcasting-terrestrial (DVB-T) and digital audio broadcasting (DAB). Next generation communication systems will require an orthogonal frequency division multiple access (OFDMA) scheme thatallows for a flexible carrier aggregation, without the need of strict synchronization among users and presents better stop-band attenuation.

multicarrier modulation scheme known as Orthogonal Frequency Division Multiplexing consists of a densely packed low frequency data symbols. The data is carried by the subcarriers. By the concept of cyclic prefix, the subcarriers are demodulated in the absence of ISI and CSI successfully. The use of cyclic prefix is not favorable for multicarrier uplink as well as cognitive radio system because CP reduces the spectral efficiency. This is not the case with FBMC modulation where the filters are spaced uniformly and are higher in selectivity to achieve minimum crosstalk. FBMC modulation based systems are complex in comparison to OFDM. FBMC does not need cyclic prefix and it provides narrowband jammers, spectrum efficient and selective systems. The development of MIMO based FBMC is very limited. FBMC finds its applications in the fields which include cognitive radio communication, MIMO communication, multiple access networks and power line communication.

This is because FBMC offers the possibility of shaping subcarrier signals with waveforms that are well-localized in both frequency and time axes.Due to its good properties, FBMC has played a major role in several recent and on-going international projects and in the 5G infrastructure public-private partnership. FBMC is being considered as the modulation of preference not only for 5G cellular networks but also for the professional mobile radio(PMR) and for satellite communications. One of the most considered FBMC schemes is based on offset quadrature amplitude modulation (OQAM), generally referred to as OFDM/OQAM.This paper concentrateson the FBMC/OQAM scheme for the reason that it is the most spectrally efficient alternative, reaching the highest symbol density in the time-frequency plane. Furthermore, it exhibits a good spectral confinement,and does not depend on the CP transmission. The channel equalization task may be hard due to the absence of CP, therefore there have been a number of alternative proposals that depends on the insertion of a CP. This work gives priority to the original FBMC/OQAM waveform, which presents outstanding spectral efficiency, and studies the challenges that it poses to MIMO processing. Differently to OFDM, the use of FBMC/OQAM in multi antenna configurations is not as simple. In general terms, one cannot depend on a mere generalization of the solutions adopted in OFDM-based systems. [7] 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.

II.RELATED WORKS

Early works in the literature that related OFDM and FBMC/OQAM for multi stream MIMO systems did not take into consideration the different signal structure of FBMC/OQAM and how to take advantage of it. This paper analyses previous works and also creates the base to designing the basic techniques, such as channel inversion and channel diagonalization. The design of MIMO techniques for FBMC/OQAM systems achieve multiplexing and diversity gains by exclusively using the knowledge of the channel state information (CSI) at the receive side. The possibility of using CSI at transmission (CSIT) opens the door to allocating many users over the same frequency resources.

III. PROPOSED SYSTEM

The proposed system focusses on the offset quadrature amplitude modulation based FBMC variant known as FBMC/OQAM which presents outstanding spectral efficiency and confinement in a number of channels and applications. The goal of the paper is to focus on the signal processing in MIMO-FBM/OQAM.

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A. Design Model

The aim of this section is to present a formulation for the FBMC/OQAM modulation scheme that unifies single-input single- output (SISO) and MIMO architectures. The SISO FBMC/OQAM transmission format introduces a time offset on the real or imaginary part of the QAM symbols, which is equal to half the symbol period. This is identical to the transmission of pulse amplitude-modulated (PAM) data symbols with a phase shift of π /2 inserted between adjacent symbols along time and frequency axes. The outcome is a weak (real-domain) subcarrier orthogonality, with the presence of an intrinsic self-interference at the received signal even when no distortion is present in the transmission link.Under ideal transmission conditions this self-interference can be easily removed as it is in quadrature with the intended signal.

1. SISO

The filters of the filter bank are the prototype pulse p(t) which time frequency shifted. The parallel data transmission splits the bandwidth into M sub bands, which are spaced Δf apart in frequency. At each subband, symbols are pulse shaped by p(t) and transmitted with rate T , where T stands for the symbol period.

The matched filter is denoted by p∗(T−t), which is time-shifted to be causal where (k+1)T corresponds to the sampling instant. This strategy permits the system to attain a fine-grained control of the spectrum, as p(t) is a low-pass filter which is band limited. The Spectral roll-off higher than zero and by allowing spectral overlapping,the waveform design is simplified and the bandwidth efficiency is increased.

Thisorthogonality condition establishes a constraint, (1/ Δf T) ≤1, on the symbol density. A prototype pulse that satisfies this constraint with equality, corresponding to minimum symbol spacing, cannot be well localized both in time and frequency symbol spacing.The time-frequency localization (TFL) with 1/ΔfT = 1 is possible when OQAM modulation is applied, by alternately shifting the parallel data transmissions in time (T/2) and in frequency (π/2).

2. MIMO

In the case of SISO, M streams are parallel transmitted i.e. one per frequency. Let us consider the case where the transmitter and the receiver are furnished with NT and NR antennas.S multicarrier signals can be multiplexed using the spatial degrees of freedom. The architecture implementation may be extremely hard if the impulse responses of the precoder and the equalizer are excessively long. This is the case with the singular value decomposition (SVD) beamforming. This problem is avoided to some extent in multicarrier modulations, specifically for FBMC/OQAM systems, by decomposing the broadband MIMO channel into a set of sub channels, so that transmit and receive processing can be performed on one sub-channel. As the frequency selectivity of the sub channels is moderate than the whole channel, the number of taps for pre- and the post-processing per sub channel is considerably reduced. S streams are spatially multiplexed on each subcarrier at the transmitter side.

3. Application of FBMC/OQAM in massive MIMO

Different variants of FBMC/OQAM have been considered in the case of massive MIMO communications. The base of massive MIMO is in minimizing the effects of multi-user interference by the use of large number of antennas at the base station. The massive MIMO and FBMC/OQAM is combined to get the best of both technologies. As the number of antennas increases, the equivalent channel that is obtained after combining the signal components of different antennas becomes smooth, so that it can be assumed flat at the subcarrier level. Hence, multi-user MIMO techniques relying on this model will be valid for FBMC/OQAM-based massive MIMO communications, subject to self-equalization.

B. MIMO-FBMC/OQAM systems without CSIT requirements: spatial multiplexing schemes

The techniques of MIMOFBMC/OQAM systems when CSI is solely available at the receiver is discussed.Importance is given to schemes that achieve spatial multiplexing gains, where NT streams are plainly mapped onto NT transmit antennas. In this case the streams can be detected jointly, or separately after performing MIMO equalization. Depending on how strong the channel frequency selectivity is, this section proposes specific techniques for highly and low frequency selective channels. When CSI is only exploited by the receiver, diversity gains can be achieved using space-timeblock-coding (STBC) As a consequence, the application of STBC to FBMC/OQAM results in ISI and ICI . To overcome the inherent error floor problem, ISI and ICI can be mitigated by interference estimation and cancellation procedures. This permits to achieve diversity gains, only for low-order modulations. Indeed, interference estimation and cancellation techniques suffer from error propagation phenomenon. When high-order modulations are used, the decision errors occur more

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often and propagate through the iterations. Therefore, the performance still presents the error floor limitation for high-order modulations. In addition, the best performance is achieved by using QAM symbols with the conventional FT lattice structure of OFDM

C. MIMO-FBMC/OQAM systems with CSIT

The CSI knowledge is available at both sides of the link. The possibility of using CSIT allows the transmitter to simultaneously serve several users using the same time/frequency resources, exploiting a space-division multiple access (SDMA) capability. In this sense, MIMO precoding and decoding matrix designs can be categorized into designs either for single- or for multi-user communication systems. This section also distinguishes between highly and low frequency selective sub channels and introduces the techniques that are more appropriate for each scenario.

1. Single-user communication systems: Highly frequency selective channels

The first attempt to jointly design the transmit and the receive processing is limited to the study of single-user MIMO (SU-MIMO) communication systems. To solve to the highest possible extent the orthogonality issues when severe channel frequency selectivity comes into play, two different alternatives have been proposed, namely: multi-stage parallel processing and multi-tap processing.

2. Single-user communication systems. low frequency selective channels

Under the assumption that the channel frequency response is almost flat at the subcarrier level, a new range of possibilities can be considered for designing the transceiver. Bearing this in mind it is assumed that the S symbols to be spatially multiplexed are linearly mapped onto the NT antennas.

D. CHANNEL ESTIMATION IN MIMO-FBMC/OQAM SYSTEMS

Acquiring CSI in FBMC/OQAM systems is a challenging task, significantly more difficult than in OFDM, due to the intrinsic interference effect. The challenge is intensified in MIMO systems, where the multi-antenna interference has also to be taken into account. The motivation behind this simplification is to formulate the problem in a way similar to OFDM. Of course, the similarity is only in the inputoutput relation appearance, since FBMC/OQAM also involves ISI/ICI. Moreover, this assumption may be quite inaccurate in communication environments involving, e.g., high data rate and/or mobility. In such cases,relying on the above assumption results in severe error floors at medium to high SNR values, which cancel the advantage of the FBMC/OQAM modulation over OFDM. The MIMO case was reviewed where the focus was on preamble-based methods.

IV SIMULATION

SIMULATION RESULTS

The comparison of SER as a function of E_S/N_0 is simulated with N_T =4, N_R=2, S=2 and M=16.The curves obtained in OFDM and FBMC/OQAM systems exhibit the same slope.The FBMC/OQAM exhibits an error floor when the multi-stage parallel architecture sets KR =1, which coincides with the conventional single-tap MMSE equalizer employed in OFDM.When the receiver combines the processing performed on two stages, which corresponds to KR =2, the error floor is not observable for the range of ES N0 under consideration. The alternative based on multi-tap equalization gives practically the same performance as the multi-stage architecture by using three taps per-subcarrier, i.e., La =1.

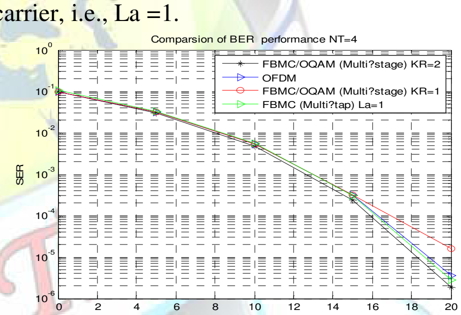

Figure 1 SER against ES/N0 in highly frequency selective channels

A MIMO system with NT =4,NR =2,S=2and NT = NR =6,S=5.The number of subcarriers is M = 1024 and the symbols belong to the 16- QAM. The BER performances of three schemes for FBMC/OQAM systems are presented and compared to that of an OFDM system.Eliminating the interference via ZF precoding, the error floor is completely removed. The degradation suffered when ZF is applied is non-existing. If S = NR ≤ NT is not satisfied, then the ZF performs poorly. In those multi-antenna configurations where the ZF does not achieve satisfactory performance, the coordinated beamforming (CBF)appears as a good candidate to improve the performance which is shown in Fig 2.

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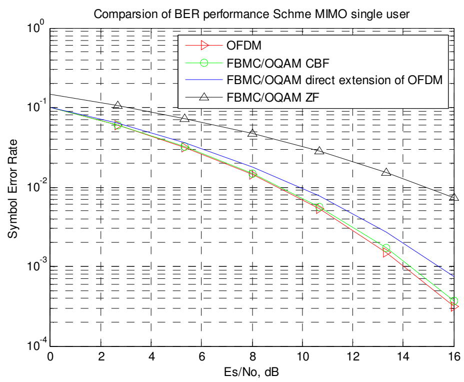

Figure 2 Comparison of the BER performances of different schemes in a single-user MIMO system where N_T=6, N_R=6 and S=5.

The presence of symbol timing offsets uniformly distributed in the range (T/8,T/4) is considered, where T represents the symbol period. The number of subcarriers is M = 1024 and the symbols are drawn from the 4-QAM constellation. The BER curves show that a single subcarrier as the guard band suffices for FBMC/OQAM to achieve the separation of signals from different users. By contrast, in case of OFDM, even if a much larger guard band with ten subcarriers is employed at the price of a severe loss of the spectral efficiency, an error floor in the BER curve is observed which is shown in Fig 3.

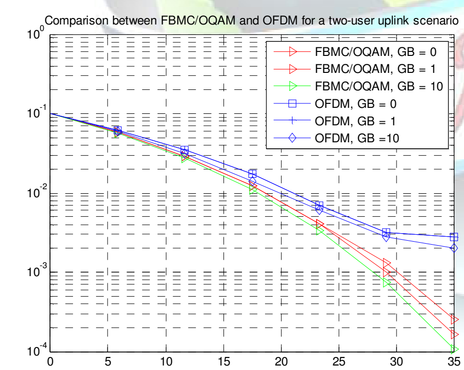

Figure 3 Comparison between FBMC/OQAM and OFDM for a two user uplink scenario in the presence of symbol timing offsets, the base stations are equipped with 2 antennas.

As it is typical in methods that rely on the flat subchannel model, a severe error floor is observed at above medium SNR values, due to the fact that the residual intrinsic interference becomes more apparent in weak noise regimes as in Fig 4.

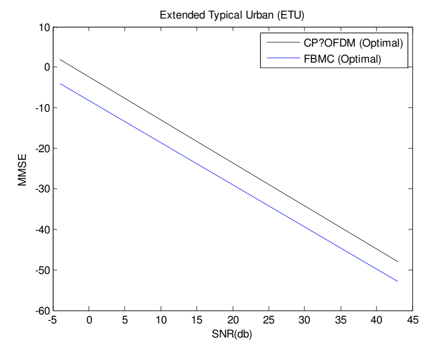

Figure 4 Estimation performance of preamble based methods for 2*2 Extended Typical Urban channel

The modulo based precoding technique is simulated where the BER vs SNR. The system performance is improved. The modulo type precoding is simulated for M=16,Nu=3,Nt=6,Nr=6,S=5 as in Fig 5.

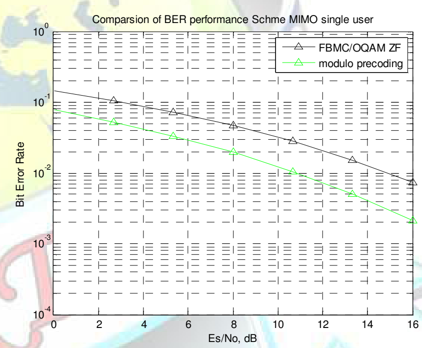

Figure 5 Comparison of BER performance and E_s/N_0 of the proposed and the existing scheme.

V.CONCLUSION AND FUTURE WORK

The signal processing problems underlying the application of FBMC/OQAM in multi antenna environment were considered with emphasis given to the most recent advances in this area. The FBMC/OQAM allows a flexible use of the spectrum. The signal processing problems in MIMO-FBMC/OQAM systems were also resolved. The Hermitianprecoding technique is implemented. The moduloprecoding technique is proposed in order to improve the system performance.The future work includes proposing a preamble design and channel estimation with virtual subcarriers, channel estimation in multiuser settings.

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