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Peak-to-average Power Ratio Pressure Potential Portion for Multi-bearer Communication in Multi end user Single-input Multiple-output Dissemination

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***Abstract*— Peak-to-average power ratio (PAPR) constrained power allocation for multicarrier transmission in multiuser single-input multiple-output (SIMO) communications is considered in this paper. Reducing the PAPR in any transmission system is beneficial because it allows the use of inexpensive, energy-efficient power amplifiers. Here, we formulate a power allocation problem for single-carrier (SC) frequency division multiple access (FDMA) and orthogonal FDMA (OFDMA) transmission with instantaneous PAPR constraints. Moreover, a statistical approach is considered in which the power variance of the transmitted waveform is controlled. Orthogonal Frequency-Division Multiple Access (OFDMA) has been currently under intense research for wireless transmission due to its robustness against multipath fading. However, it has some limitations such as the Peak-to-average power ratio (PAPR), which restricts its use. It reduces the efficiency of the system. The aim of this paper is to analyze the performance of system over clipping technique. Wavelet based system is also suggested. Results of both systems are compared.**

***Index Terms*—** Single-input multiple-output, Single-Carrier, FDMA, OFDMA, PAPR.

I. Introduction

Reducing peak to average power ratio (PAPR) in any transmission system is always desirable as it allows use of more efficient and cheaper amplifiers at the transmitter. Recent work on minimizing the PAPR in single carrier frequency division multiple access (FDMA) transmission can be found.Where they propose different precoding methods for PAP R reduction. However, these methods do not take into account the transmit power allocation, the channel nor the receiver . Due to the problems related to inter-symbol-interference (ISI) and multi-user interference (MUI) in single carrier FDMA, efficient low-complexity channel equalization techniques are required. Iterative frequency domain equalization (FDE) technique can achieve a significant performance gain as compared to linear FDE in frequency selective channels. Therefore, it is considered as the most potential candidate to mitigate ISI and MUI. However, to exploit the full merit of iterative receiver, the convergence properties of an iterative receiver needs to be taken into account at a transmitter side. This issue has been thoroughly investigated.

In order to transition from today's 3rd generation (3G) communications systems to meet the needs of 4th generation (4G) systems, the 3rd Generation Partnership Project (3GPP) has released the Long Term Evolution (LTE) specification. Among the numerous differences between these generations are changes in the physical layer (PHY), specifically in the modulation and multiple access schemes. While its parent generation relied on variations of Code Division Multiple Access (CDMA), LTE implements Orthogonal Frequency Division Multiplexing (OFDM) for its downlink and Single-Carrier Frequency-Division Multiple Access (SC-FDMA) for its uplink. The purpose of this project is to investigate the reasoning for this discord between uplink and downlink modulation schemes; specifically, why Orthogonal Frequency Division Multiple-Access (OFDMA) was not used as the uplink.

OFDMA and SC-FDMA are the multiple-access versions of OFDM and a similar modulation scheme, Single-Carrier Frequency-Domain Equalization (SC-FDE). In order to compare the differences between the multiple-access methods, it is important to first cover the differences between their underlying modulation schemes.

The bases used for comparison will be capacity, outage probability and peak-to-average power ratio (PAPR). While the first two bases have always been traditionally used in analyses, PAPR is especially important for the uplink of mobile devices. Amplifiers used in circuits today have a linear region in which they must operate so as not to introduce signal distortion, and it is ideal to run with maximum amplification. However, if there is a high PAPR, the device is forced to run with lower amplification so the peak power does not lie in the non-linear gain region. The farther these amplifiers are operated from the peak, the less power efficient the devices become, leading to increased power consumption and while this might not be very important for a base station, it will reduce drain batteries on mobile devices more quickly. Therefore it is important to keep a low PAPR on the uplink.

II. RELATED WORK

Transmission power allocation in single-carrier multiple-input multiple-output (MIMO) systems with iterative frequency-domain (FD) soft cancellation (SC) minimum mean-squared error (MMSE) equalization is considered. A novel framework for transmission power minimization subject to equalizer convergence constraints, referred as convergence constrained power allocation (CCPA) method, is proposed in [1] based on extrinsic information transfer (EXIT) chart analysis. The proposed method decouples the spatial interference between the streams using singular value decomposition (SVD), and minimizes the transmission power while achieving the target mutual information for each stream after iterations at the receiver. We show that the transmission power optimization can be formulated as a convex optimization problem. Three CCPA methods, one approximately optimal, and other two heuristic methods inspired by the Lagrange duality are derived. The numerical results demonstrate that the proposed scheme outperforms the existing linear precoding schemes. Moreover, the proposed heuristic schemes can achieve performance close with that of the approximately optimal method in terms of the equalizer convergence properties as well as transmission power.

In [2] the authors propose a method for the reduction of peak-to-average transmit power ratio of multicarrier modulation systems, called selected mapping, is presented, which is appropriate for a wide range of applications. Significant gains can be achieved by selected mapping whereas complexity remains quite moderate.

The authors in [3] propose a very effective and flexible peak power reduction scheme for orthogonal frequency division multiplexing (OFDM) with almost vanishing redundancy. This new method works with arbitrary numbers of subcarriers and unconstrained signal sets. The core of the proposal is to combine partial transmit sequences (PTS) to minimise the peak-to-average power ratio distortion.

Partial transmit sequence (PTS) is a promising technique for peak-to-average-power ratio (PAPR) reduction in orthogonal frequency division multiplexing (OFDM) systems. Computation of optimal PTS weight factors via exhaustive search requires exponential complexity in the number of subblocks; consequently, many suboptimal strategies have been developed to date. In [4], the authors introduce an efficient algorithm for computing the optimal PTS weights that has lower complexity than exhaustive search.

In [5], the problem of reducing the peak-to-average-power ratio (PAPR) in an orthogonal frequency-division multiplexing system is considered. We design a cubic constellation, called the Hadamard constellation, whose boundary is along the bases defined by the Hadamard matrix in the transform domain. Then, we further reduce the PAPR by applying the selective-mapping technique. The encoding method, following the method introduced in the work of Kwok, is derived from a decomposition known as the Smith normal form. This new technique offers a PAPR that is significantly lower than those of the best-known techniques without any loss in terms of energy and/or spectral efficiency, and without any side information being transmitted. Moreover, it has a low computational complexity.

III. SYSTEM ANALYSES

In existing system, we formulate a power allocation problem for single-carrier (SC) frequency division multiple access (FDMA) and orthogonal FDMA (OFDMA) transmission with instantaneous PAPR constraints. Moreover, a statistical approach is considered in which the power variance of the transmitted waveform is controlled. The constraints for the optimization problems are derived as a function of transmit power allocation and two successive convex approximations (SCAs) are derived for each of the constraints based on a change of variables (COV) and geometric programming (GP). In this section, the system model of uplink transmission in a single-cell system with U single-antenna users and a base station with NR antennas is presented. The channel state information (CSI), including an instantaneous channel impulse response and the second moment of additive thermal noise, is assumed to be perfectly known both at the TX and RX.

A. Multiple Access Methods

In order to support more than one simultaneous transmission, multiple access techniques are employed. Both of the techniques that will be analysed in this project achieve are forms of Frequency Division Multiple Access (FDMA). The basic premise of converting modulation schemes such as OFDM and SC-FDE to their FDMA counterparts, OFDMA and SC-FDMA is assigning each user a subset of the available subcarriers and having the users transmit only on at these frequencies. In this section capacity and PAPR will be investigated.

Orthogonal Frequency Division Multiple-Access (OFDMA)

Orthogonal Frequency-Division Multiple Access (OFDMA) is a multi-user version of the popular orthogonal frequency-division multiplexing (OFDM) digital modulation scheme. Multiple access is achieved in OFDMA by assigning subsets of subcarriers to individual users as shown in the illustration below. This allows simultaneous low data rate transmission from several users. Based on feedback information about the channel conditions, adaptive user-to-subcarrier assignment can be achieved. If the assignment is done sufficiently fast, this further improves the OFDM robustness to fast fading and narrow-band cochannel interference, and makes it possible to achieve even better system spectral efficiency.

SC-FDMA is the multiple access version of Single-Carrier Frequency-Domain Equalization (SC-FDE), which is similar to OFDM, in that they both perform channel estimation and equalization in the frequency domain. The system model for this access method can be seen in Figure 7 [9]. Multiple accesses is achieved in frequency domain in SC-FDMA. Thus to transition from SC-FDE to SC-FDMA requires division frequency amongst frequencies. This is achieved by the first performing an N-point FFT on the output of the symbol mapper, and mapping the output of the FFT to N of M subcarriers, with M = QN where Q is an integer called the bandwidth expansion factor of the symbol, which is effectively the number of simultaneous users that the system supports [9]. Afterwards the M-point IFFT converts the signal back into time domain. Likewise in the demodulator, only N of the M frequencies of the output of the FFT correspond to this user, so those N values are equalized and an N-point IFFT is performed to get the original signal back.

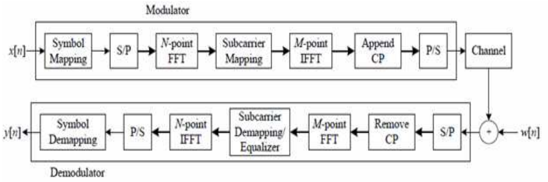


Fig. 1: Discrete-time system model for SC-FDMA

An important consideration to be made is how the N points of the signal are mapped to the M subcarriers of the system. Two main strategies exist: use N adjacent subcarriers, called localized FDMA (LFDMA) or distribute the N values across the M subcarriers using every Qth subcarrier, called interleaved FDMA (IFDMA). The LTE specification follows LFDMA as it assigns each users a set of 12 adjacent subcarriers. As explained in [9], a disadvantage of IFDMA is that it is very sensitive to frequency offset like OFDMA since different users take adjacent subcarriers. LFDMA, however, is much less affected by this because it only has at most two adjacent users.

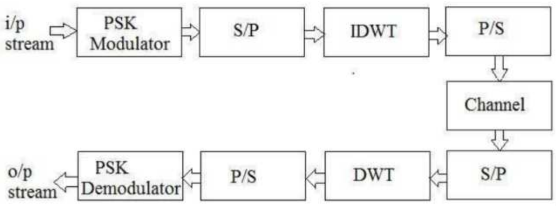


Fig. 2: Proposed block diagram

B. *Wavelet Based OFDMA System (DWT-OFDMA)*

This section discusses the alternative way to implement OFDM using DWT. In DWT-OFDM, the time-windowed complex exponentials are replaced by wavelet "carriers", at different scales (j) and positions on the time axis (k). These functions are generated by the translation and dilation of a unique function, called "wavelets mother" and denoted by ψ. The wavelet carriers exhibit better time-frequency localization than complex exponentials while DWT-OFDM implementation complexity is comparable to that of FFT-OFDM. The key point orthogonality is achieved by generating members of a wavelet family, according to the below Eq.

$\psi j, = 2 - j\ 2\ (2 - jt - k)$

To obtain finite number of scales, scaling function (t) is used. DWT-OFDM symbol is considered as the weighted sum of wavelet and scale carriers, as expressed in Eq. below, which is close to the Inverse Wavelet Transform (IDWT).

$$\{\psi_{j,k}(t), \psi_{m,n}(t)\} = \begin{cases} 1, \text{if } j = m \quad , k = n \\ 0, \text{ otherwise} \end{cases}$$

The data symbols are seen by IDWT modulator as sequence of wavelet and approximation coefficients. According to previous Eq. J is the scale with poorest time resolution and best frequency localization of the carriers. For computing IDWT, Mallat's algorithm based on filter bank is used instead of Eq. is expressed below.

$st = jsjkej,t\psi j,k + kaj\ ,\ k\varphi j,k(t)$

At the output of the filter discrete version of DWT-OFDM symbol is obtained, with impulse response of filters (low-pass and high-pass) decided by the wavelet mother.

IV. SIMULATION RESULTS

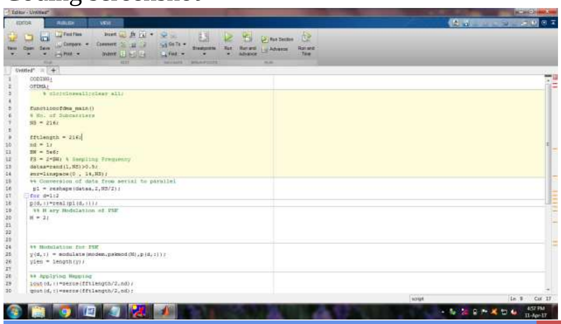
Matlab can have several "toolboxes" added to it for specific applications. The list of the toolboxes installed can be obtained by typing the "help" command. If the Digital Signal Processing toolbox is installed, the user will see the following three lines in the list:

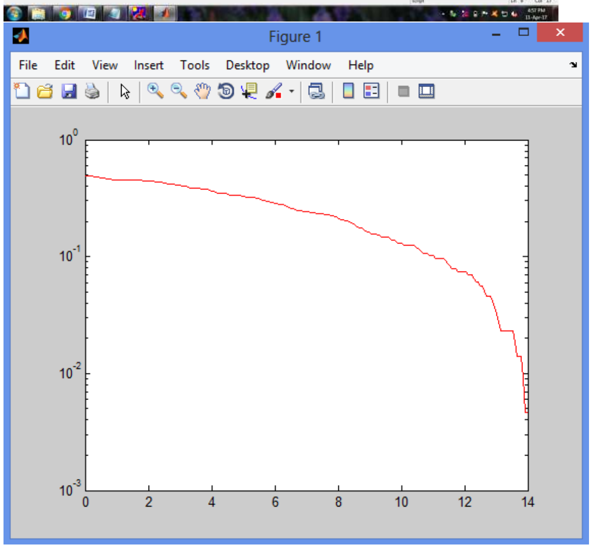
signal\signal - Signal Processing Toolbox.
signal\siggui - Signal Processing Toolbox GUI
signal\sigdemos-Signal Processing Toolbox Demonstrations

To obtain the list of functions available under each, the user can type "help signal", "help siggui" and "help sigdemos", respectively.

A. *Result analysis*

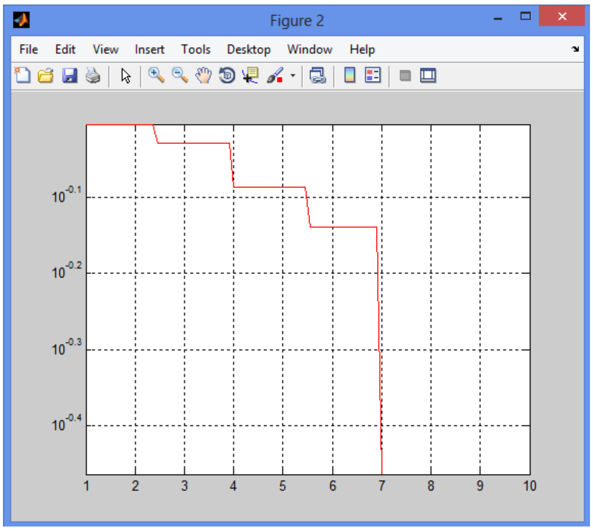
Coding screenshot





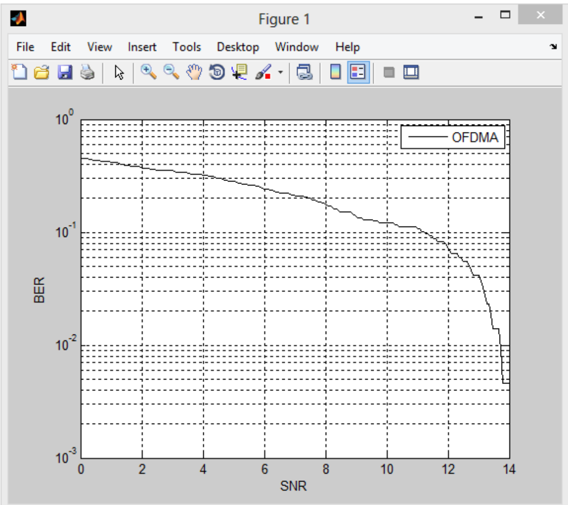
B. *SNR VS BER*

Complementary cumulative distribution function (CCDF)



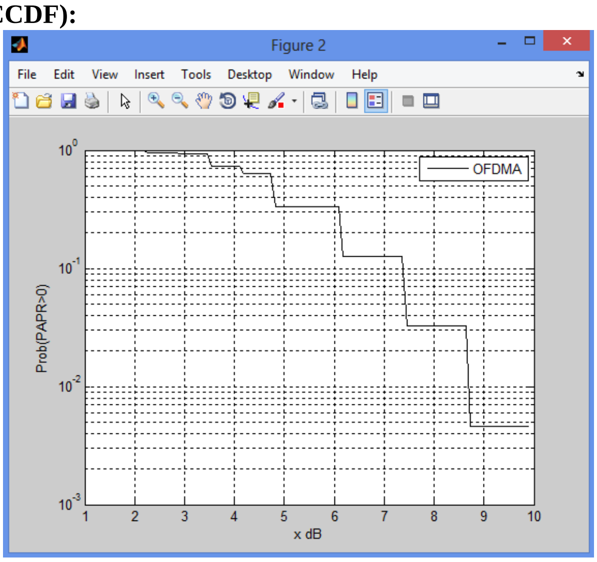
xlabel('x dB')
ylabel('Prob(PAPR>0)')

C. SC-FDMA



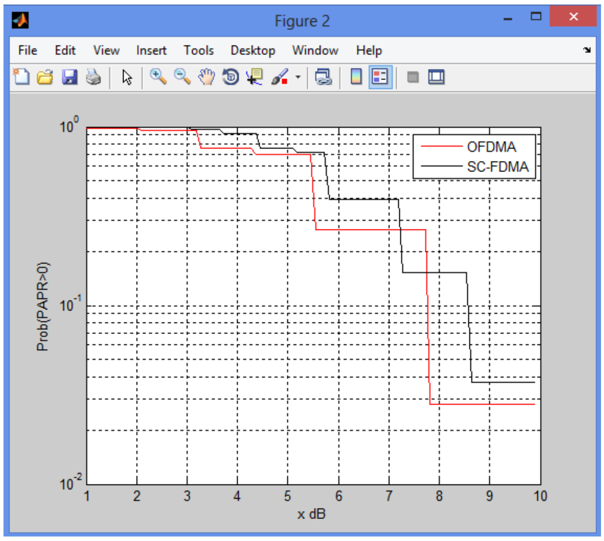
D. SNR VS BER

Complementary cumulative distribution function (CCDF):

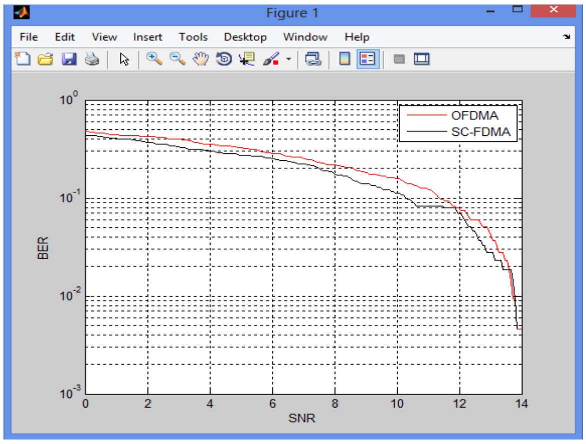


E. OVERALL RESULT

Complementary cumulative distribution function (CCDF)



F. SNR VS BER



V. CONCLUSION

In this paper, we have formulated PAPR constrained power allocation problem for multicarrier transmission with iterative MMSE multiuser multiantenna RX. We derived an analytical expression of PAPR as a function of transmit power allocation for SC-FDMA and OFDMA. The derived PAPR constraints are applicable for any normalized data modulation format. In addition, a statistical approach considering the transmission power variance constrained power allocation was derived. Power efficiency is an important criterion to consider when selecting a modulation scheme in mobile uplinks because battery usage is an important concern. In this project it became clear that SC-FDMA is better choice in this regard. Their PAPRs achieve lower values on average, mainly due to the fact that they map their input bits to time symbols, as opposed to OFDMA which map them directly to frequency symbols.. OFDMA is also sensitive to frequency offsets, causing it to achieve lower capacities for high SNRs. Although there are many variations of OFDMA and SC-FDMA, comparing the basic models of each type, one can conclude that SC-FDMA is the better option for a cellular uplink in LTE, because of its higher efficiency due to low PAPR, its lower sensitivity to frequency offset because it has at most only two adjacent users, and its capacity is about the same as OFDMA.

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