Beamforming and PAPR reduction in multi user MIMO OFDM systems

Ms. Sapana S. Kamble, Prof. Kailash T. Jadhao

Abstract—**In Multiple Input Multiple Output Orthogonal Frequency Division Multiplexing system using beamforming improve the receive Signal to Noise Ratio. In the transmission signals after beam forming the Peak-to-Average Power Ratio (PAPR) is a major issue in Orthogonal Frequency Division Multiplexing systems, High Peak to Average Power Ratio is complicated to design the power amplifier and also increases the power consumption. Analysis of Peak to Average Power Ratio in Multiple Input Multiple Output Orthogonal Frequency Division Multiplexing systems has beam forming schemes, MRT (Maximum Ratio Transmission) and EGT (Equal Gain Transmission). Maximum Ratio Transmission systems have better improvement compare to that of Equal Gain Transmission systems in Peak to Average Power Ratio reduction. In Maximum Ratio Transmission OFDM systems improve both PAPR and bit error rate, also EGT OFDM systems improves PAPR reduction and lesser improvement in bit error rate when compare to Maximum Ratio Transmission system.**

Index Terms-**MIMO OFDM, beamforming, precoding, peak-to- average power ratio, PAPR, low power, maximum ratio transmission, MRT, equal gain transmission, EGT, extreme value theory.**

I. INTRODUCTION

Multiple-input Multiple-output orthogonal frequency division multiplexing is widely used in current and next generation broadband wireless communications, because it can provide high data rate transmission over multipath fading channels.[2]. Among the MIMO techniques, beam forming has been widely adopted in communication standards, e.g., LTE, Wi- MAX and Wi-Fi applications, because it can achieve full diversity, which results in a reliable transmission. Orthogonal frequency divison multiplexing i.e OFDM systems suffer from high peak-to-average power ratio. High PAPR leads to high effort in designing the power amplifier in order to maintain a wide linear region for preventing signal clipping, which therefore increases not only hardware complexity but also power consumption. The PAPR issue is worse when beam forming is applied in OFDM systems, because the dynamic range of the signals increases after beam forming.[3]

Many methods have been proposed for reducing the PAPR including deliberate clipping, compounding, probabilistic methods, and coding. These methods may more or less distort signals and decrease the data rate. The most straightforward technique for PAPR reduction is via clipping peak signals before passing them to the PA. However, clipping signals induces in-band and out-of-band distortion and requires additional signal processing techniques to reconstruct the received signals. Another category of methods to reduce the PAPR is through probabilistic schemes such as partial transmit sequence, selected mapping and sign adjustment[5][10]. The objective of probabilistic methods is to reduce the probability that peak power exceeds a certain PAPR threshold. These methods demand that the transmitter sends side information to the receiver. Consequently, the data rate decreases due to the side information, and the transmitted signals cannot be correctly reconstructed if the transmitted side information is polluted. Moreover, although there has been extensive research for PAPR on OFDM systems, to the best of the authors knowledge, few studies have been conducted in analyzing the PAPR for beam forming MIMO OFDM systems and developing corresponding PAPR reduction methods, which are especially important in practice, since most modern communication systems adopt beam forming MIMO OFDM techniques and Green communications is a worldwide trend to save power consumption. The above discussion inspires us to learn how PAPR increases if beam forming is adopted in OFDM systems, and also the corresponding mitigation methods for PAPR reduction.

In this proposed system we analyze the PAPR performance for single user MIMO OFDM systems adopting either one of the two most commonly used beam forming schemes, i.e., maximum ratio transmission and equal gain transmission. MRT is the most favourable beam forming scheme in terms of receives SNR, but the complications of PA design is more for MRT than EGT. Here we use the Extreme Value Theory and order statistics to derive the CCDF of PAPR for EGT and MRT OFDM systems. First, we found that EGT OFDM systems have constant power property for different OFDM blocks and different RF transmits branches. Thus the PAPR characteristic can be approximately obtained by simultaneously considering Mt unprecoded OFDM systems, where Mt is the number of transmit antennas. In other words, the PAPR for EGT OFDM systems is the same as that of unprecoded OFDM systems simultaneously transmitting Mt data streams.

II. PROPOSED SYSTEM

PAPR reduction methods for both MRT OFDM and EGT OFDM systems. In the proposed system there is no need to send side information from the transmitter to the receiver. In MRT OFDM systems, the proposed algorithm decreases the PAPR as well as improves the bit error rate performance. Beam forming (or preceding) techniques have been widely adopted in modern MIMO OFDM systems. Using beam

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forming can significantly improve the receive SNR of OFDM systems. However, after beam forming the peak-to-average power ratio (PAPR) of the combined signal becomes worst, which is a major problem of OFDM systems. High PAPR leads to increase in consumption of power as well as complications in the PA design. we theoretically analyze the PAPR performance of MIMO OFDM systems that adopt any one of the two popular beams forming schemes, *i.e.* MRT (maximum ratio transmission) and EGT (equal gain transmission). The analysis considers different numbers of channel taps after sampling. The results may provide important reference for practical designs when evaluating the required power amplifiers and power consumption.

III. Analysis of Peak to Average Power Ratio

In terms of PAPR MRT OFDM systems performs worst than EGT OFDM systems. PAPR reduction algorithms are proposed for both MRT OFDM and EGT OFDM systems. For MRT OFDM systems, algorithm can improve both PAPR and bit error rate but for EGT OFDM, algorithm improves PAPR but bit error rate decreases slightly. In this paper, we examine the PAPR performance for multi user MIMO OFDM systems adopting either one of the two most commonly used beam forming schemes, *i.e.*, maximum ratio transmission (MRT) and equal gain transmission(EGT). MRT is the most favourable beam forming scheme in terms of receive SNR, but the PA design for MRT is more complicated than EGT. Under Rayleigh fading channels the maximum SNR loss between MRT and EGT is only 1.05 dB. Two types of average power: one is block average power $P_{av}$and the other is long-term average power the block average power is the average power of an OFDM block at a specific transmit branch, *i.e.*

$$P_{av} = \frac{1}{T}\int_0^T \left[S^{(i)}(t)\right]^2 dt$$

While the long-term average power is the expectation of the block average power, i.e.

$$\bar{P}_{av} = E[P_{av}]$$

The baseband PAPR of the beam forming OFDM system is defined as

$$\max_{0\le i\le M_{t-1}}\left\{PAPR^{(i)}\right\} = \max_{0\le i\le M_{t-1}}\left\{\max_{0<t\le T}\frac{S^{(i)}(t)^2}{\bar{P}_{av}}\right\}$$

IV. Maximum Ratio Transmission(MRT)

MRT is the most favourable beam forming scheme in terms of receive SNR, but MRT is more complicated than EGT in terms of PA design. In the proposed algorithm there is no need to send side information from the transmitter to the receiver. For MRT OFDM systems, the proposed algorithm reduces the PAPR as well as upgrades the bit error rate performance. This satisfying result is obtained thanks to the motivation from the derived results. The proposed algorithm makes an effort to adjust the power at some subcarriers as close as possible after beamforming. Both the PAPR and the bit error rate performance are improved simultaneously due to the power equalization of the subcarriers.

PAPR Reduction Algorithm for MRT OFDM Systems

MRT is the most favourable beam forming scheme, and can achieve better receive SNR than EGT. MRT has different average power for different transmit branches as well as for different OFDM blocks. Hence MRT does not have constant block average power and the long-term average is needed to identify the operation region of power amplifier. In MRT the power varies which unavoidably increases the PAPR. As a result, it not only complicates the design of the PA but also leads to increase in power consumption. Moreover, the PAPR analysis for MRT OFDM systems is more complicated than that for EGT OFDM systems because *1*) *Pav* is no longer a constant, and *2*) different numbers of channels taps after sampling *L* lead to different MRT vectors and different values of PAPR. To obtain the PAPR of MRT OFDM systems, again, we first focus on a specific transmit branch, and then extend the results to all transmit branches. The MRT beamforming vector can be obtained from the right singular vector corresponding to the maximum singular value in MIMO/MISO channels. The PAPR statistics for MIMO and MISO channels should be the same, because their right singular vectors are both with the conditional Haar distribution.

V. Equal Gain Transmission(EGT)

The proposed algorithm makes an effort to adjust the power at some subcarriers as close as possible after beamforming. Since the subcarrier power is equalized in a certain level, both the PAPR and the bit error rate performance are improved simultaneously. For EGT OFDM systems, the proposed algorithm can reduce the PAPR, but it decreases the bit error rate slightly. Finally, simulation results are provided to show the accuracy of the derived theoretical PAPR results and the performance improvement achieved when using the proposed PAPR mitigation algorithms.

PAPR Reduction Algorithm for EGT OFDM Systems

The PAPR of one particular transmit branch for EGT OFDM systems is equal to that of an unprecoded OFDM systems. Hence, the PAPR reduction algorithms for unprecoded OFDM systems can be applied to EGT OFDM systems. In EGT OFDM systems different ransmit branches and different OFDM blocks has constant power; also changing phases of subcarriers can reduce the PAPR of OFDM systems Therefore, we change the subcarrier phases corresponding to the largest effective channel gains, because the error rate performance is dominated by the subcarriers corresponding to the smallest effective channel gains. By doing this, we can effectively reduce the PAPR, yet the error rate performance is only slightly degraded.

VI. Results

The proposed PAPR reduction algorithms can effectively reduce the PAPR for both MRT and EGT OFDM systems. Also the performance is improved for MRT OFDM systems as compared to EGT OFDM systems as the BER degrades slightly in EGT.

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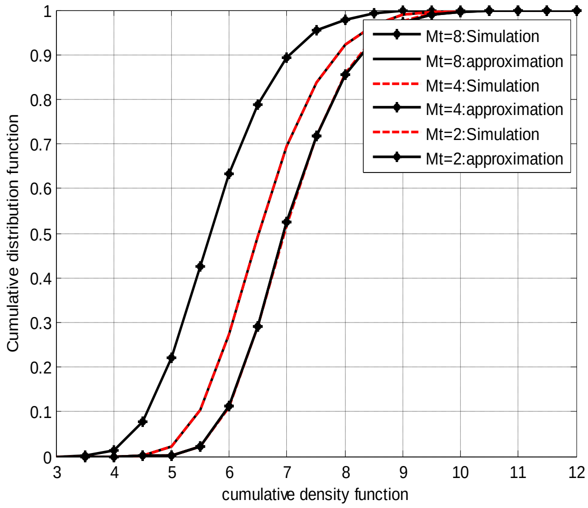

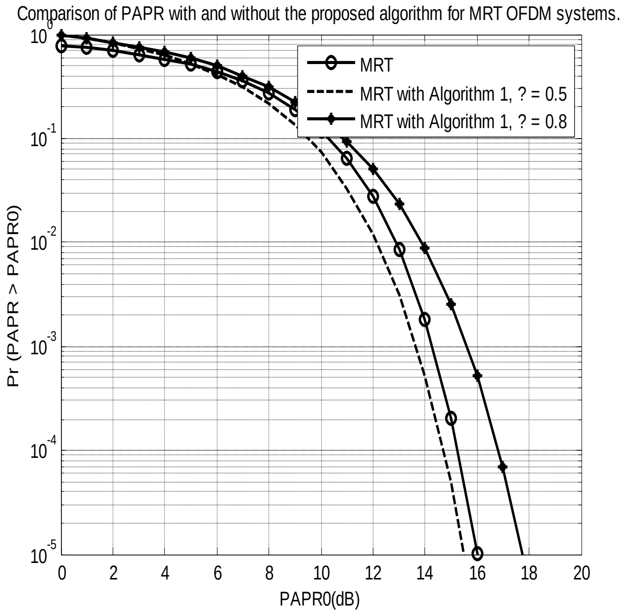

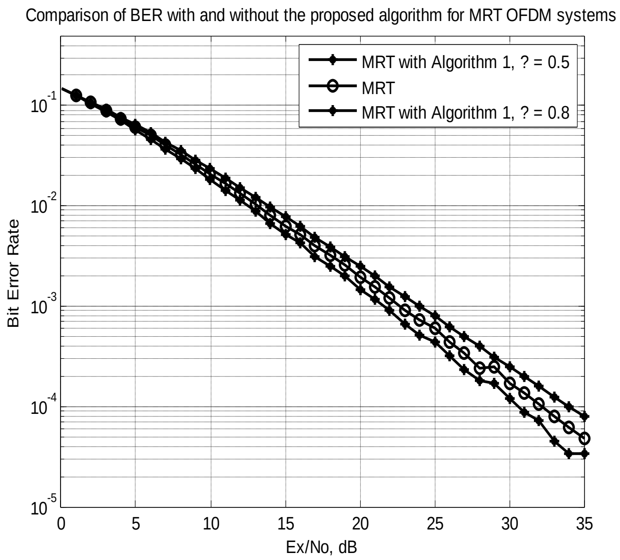

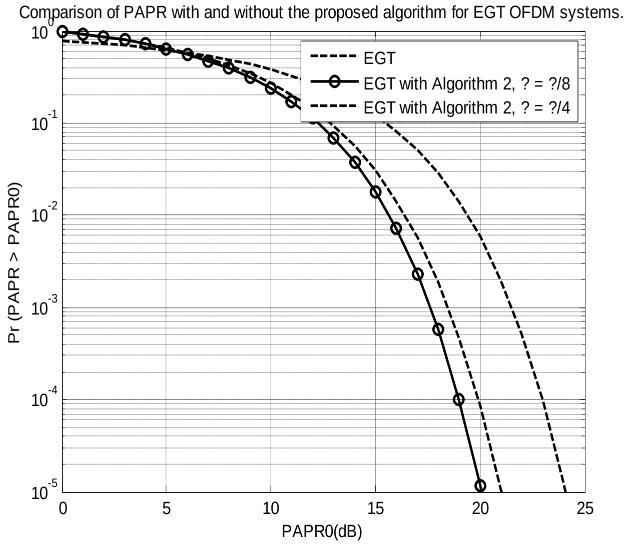

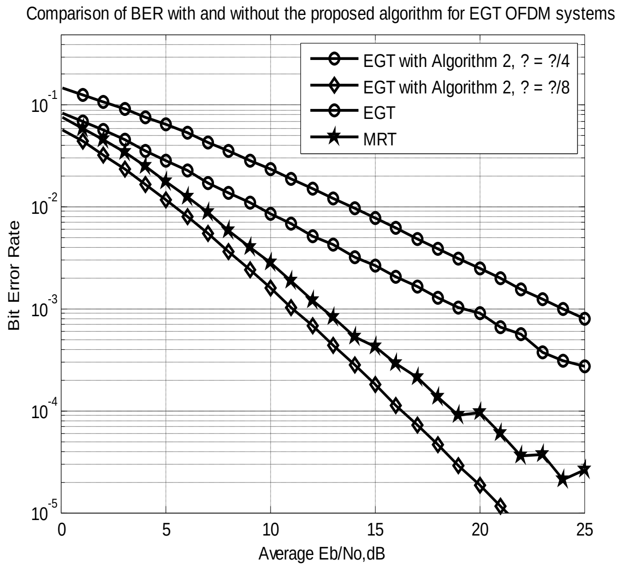

VII. CONCLUSION

The PAPR performance and corresponding mitigation algorithms for beamforming OFDM systems. We practically simulated the PAPR distribution for both MRT as well as EGT OFDM systems in terms of PAPR. Therefore, although MRT is the most favourable beamforming technique, which can achieve better receive SNR as compared to EGT, butEGT may be a preferred solution due to its superior PAPR performance in OFDM systemswhen the cost of the PA and the power consumption are taken under consideration. Moreover, we propose PAPR reduction algorithms for both MRT OFDM and EGT OFDM systems.

The performance improvement using the proposed algorithm is more noticeable in MRT OFDM systems because both the PAPR and the bit error rate performance are improved.

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