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RESEARCH ARTICLE

EFFECTIVE REDUCTION OF PEAK-TO-AVERAGE POWER RATIO IN MIMO OFDM SYSTEMS BY NONLINEAR COMPANDING TRANSFORM

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ABSTRACT

Today we want fast ways of communication; research on even more faster alternatives is going. In present time, 4th generation wireless communication standards is among one of such technologies. The building block of this technology is MIMO-OFDM system. But one of the drawbacks associated with OFDM is high PAPR. In this paper, we propose a new nonlinear companding algorithm that transforms the MIMO OFDM signals into the desirable statistics form defined by a linear piecewise function. By introducing the variable slopes and an inflexion point in the target probability density function, more flexibility in the companding form and an effective trade-off between the PAPR and bit error rate performances can be achieved. The presented theoretical analyses are well verified via computer simulations.

INTRODUCTION

MIMO-OFDM (Stuber *et al.*, 2004), technique can be used in wireless communication systems to achieve gigabit transmission. It enables high capacities suited for Internet and multimedia services, increases the range and reliability. It also increases diversity gain and enhance system capacity on a time-varying multipath fading channel improving power-spectral efficiency in wireless communication systems besides optimizing the power efficiency. We need more sophisticated technology for higher and faster data transmission and reception. This can be achieved by 4G wireless technology (Krenik 2008). Antennas can be improved by applying a technique known as MIMO, or multiple-input multiple-output, and the signals can be improved by the modulation technique of OFDM, or orthogonal frequency division multiplexing. This concept, as a whole, is known as MIMO-OFDM, and is used as the basis of the 4G technology. When a signal propagates through a wireless medium from transmitter to receiver, it is obstructed by certain parameters on its way and the signal travel through a number of different paths known as multipath. While propagating the signal power drops due to path loss and fading. Fading of the signal can be controlled by different diversity techniques. To obtain diversity, the signal is transmitted through multiple independent fading paths e.g. in time, frequency or space and combined constructively at the receiver. Multiple input- multiple-output (MIMO) (Soma *et al.*, 2002) exploits spatial diversity by having several transmit and receive antennas. OFDM is multicarrier modulation technique known for its capability to mitigate multipath.

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In OFDM, a high speed data stream is divided into "N" narrowband data streams and is modulated using subcarriers which are orthogonal to each other and the information is transmitted on each sub carrier. On each subcarrier channel, lower data rate brings longer symbol duration. The symbol duration is made even longer by adding a cyclic prefix to each symbol. As long as the cyclic prefix is longer than the channel delay spread, inter symbol interference (ISI) free transmission is obtained through OFDM. In OFDM the frequency spacing between sub carriers is selected such that the sub carriers are mathematically orthogonal to each other. The subcarriers in OFDM (Kabir 2008) have the minimum frequency separation required to maintain orthogonality of their corresponding time domain waveforms, still the signal spectra corresponding to the different subcarriers overlap in frequency domain. OFDM is well suited for transmission of high data rate applications in fading channels due to its robustness to inter symbol interference. IFFT is performed at the transmitter and FFT at the receiver, resulting in conversion of wideband signal affected by frequency selective fading, into "N" narrowband flat fading signals. Therefore, simpler equalizer is required at the receiver. OFDM is used for dedicated short-range communications (DSRC) for road side to vehicle communications and as a backbone for fourth-generation (4G) mobile wireless systems.

To overcome this issue, various methods have been developed (Jiang and Wu 2008), among which, nonlinear companding transform (NCT) is an efficient solution in reducing the PAPR of MIMO OFDM signal. The concept of NCT was first introduced in (Wang *et al.,* 1999), which used the -law companding and could significantly outperform the traditional clipping. Earlier NCT methods have primarily focused on designing the nonlinearity of the transfer curve (Huang *et al.,* 2001; Yang *et al.,* 2007). Later, the work of (Huang *et al.,* 2004) first indicated the importance of exploiting the statistical characteristics of the OFDM signal. Up to now, several such NCT methods have been proposed, e.g. the exponential companding (EC) in (Jiang *et al.,* 2005), the uniform companding (UC) in (Jaing *et al.,* 2017), the piecewise companding (PC) in (Hou *et al.*, 2010), and the trapezium or trapezoidal companding (TC) in (Hou *et al.,* 2009; Jeng and Chen 2011), etc. Intuitively, by compressing large signals and enlarging small ones, both the PAPR reduction and immunity of small signals from noise can be achieved (Huang *et al.,* 2001). However, it isworth noting that NCT is an extra pre-distortion operation applied to transmitted signal, which results in performance degradation and increased sensitivity to the HPA. It was pointed in (Huang *et al.,* 2004) that, due to the disadvantages of nonlinear distortion, such transform should be designed cautiously so that the amount of clipped signal is as little as possible. For this reason, how to reallocate the power as well as the statistics of MIMO OFDMsignal more reasonably to reduce the impact of companding distortion is the key challenge for a well-designed NCT method. Moreover, a flexible and effective trade-off among the overall performance of OFDM system with respect to the reduction in PAPR (power efficiency), bit error rate (BER), spectral re-growth (bandwidth efficiency), and the implementation complexity also should be considered.

In this paper, further motivated by the observation above we propose a new NCT algorithm which transforms the Gaussian distributed signal into a desirable distribution form defined by a linear piecewise function with an inflexion point. Compared to the previous methods, this algorithm can significantly reduce the impact of companding distortion on the BER performance by choosing proper transform parameters. The analytical expressions regarding the achievable reduction in PAPR, signal attenuation factor, and the selection criteria of transform parameters are derived and verified through computer simulations.

SYSTEM DESIGN MODEL

MIMO-OFDM System

The most important need for a MIMO-OFDM system is that with the development of wireless data and multimedia applications, the demand on transmission rate and QoS assurance of wireless communication system is correspondingly rising which could not be served by MIMO or OFDM systems separately. As discussed in above about the important properties of MIMO and OFDM system, when we combine both these systems, we get MIMO-OFDM system. MIMO-OFDM (Kabir 2008), technique can be used in wireless communication systems to achieve gigabit transmission. It enables high capacities suited for Internet and multimedia services, increases the range and reliability. It also increases diversity gain and enhance system capacity on a time-varying multipath fading channel improving power-spectral efficiency in wireless communication systems besides optimizing the power efficiency. Services like multimedia, very fast broadband etc are also available with 3G but the Qos is not there. The user do not enjoy the kind of services he/she should get because of less speed of communication. This technology guarantees each user's quality of service requirements, including bit-error rate and data rate and as a result ensures fairness to all the active users. It allows transmission over highly frequency selective channels at a reduced Bit Error Rate with high quality signal.

The increased capacity, coverage and reliability is achievable with the aid of MIMO techniques. As MIMO can be combined with any modulation or multiple access technique, therefore the implementation of combination of MIMO and OFDM is more efficient. OFDM has the property of robustness against multipath delay spread. This is achieved by having a long symbol period, which minimizes the inter-symbol interference (Jiang and Wu 2008). MIMO, can be used either for improving the SNR or data rate. Therefore clubbing of both these techniques result in a new technique which is very helpful when aiming at the design of very high-rate wireless mobile systems. One of the advantage of this system is reduced BER. The BER of this system is quite less as compared to an OFDM system. By saying higher data rate, we mean more number of bits per unit time. For a fixed value of SNR we can achieve less bit error rate, so we can say that we have an improvement in SNR or we can say that we have less error probability of bits resulting in higher data rate. As we go on increasing the number of antennas on transmitter and receiver side, the BER is further reduced because of diversity

Peak to Average Power Ratio (PAPR)

As we discussed some of the advantages of OFDM which makes it a strong contender for MIMO-OFDM systems. But OFDM has a disadvantage also which is PAPR(peak to average power ratio). PAPR is the ratio between the maximum power and the average power of the complex pass band signal sn,

$$PAPR = \frac{P_{peak}}{P_{avg}} = 10\log\frac{max\ f(t)(|s_n|^2)}{E(|s_n|^2)}$$

Where, $Ppeak$ is the peak output power, $Pavg$ is the average output power, E. denotes the expected value, sn represents the transmitted OFDM signals which are obtained by taking IFFT operation on modulated input symbols SK . sn can be expressed as

$$s_n = \frac{1}{\sqrt{N}}\sum_{k=0}^{N-1} S_k W_N^{nk}$$

The PAPR (Tao Jiang and Yiyan Wu 2008) puts a stringent requirement on the power amplifier and reduces the efficiency in the sense that a higher input back off factor is needed before the peaks in the signal experience significant distortion due to power amplifier nonlinearity.

Nonlinear Companding Transform (NCT)

Generally, an OFDM signal is the sum of independent data symbols modulated by phase-shift keying (PSK) or quadrature amplitude modulation (QAM). In discrete-time domain, since the Nyquist rate samples might not represent the peaks of the continuous-time signal, it is preferable to approximate the true PAPR on an oversampled signal. The basic idea of the proposed algorithm is to transform the statistics of the amplitude $|x_n|$into the desirable PDF defined by a piecewise function, which consists of two linear functions with an inflexion point. The principle of NCT is described as follows. The original signal is companded before converted into analog waveform and amplified by the HPA. The companded signal is denoted as, where is the companding function that only changes the amplitude of. In the case of additive Gaussian white noise (AWGN) channel, the received signal can be recovered by the de-companding function. The desired companding form i.e. the ultimate PAPR, while controlling the average output power in this transform. The transfer curves of this algorithm with various parameters, that we can see that the transform can achieve more reduction in the PAPR with or increasing. Especially, it is noteworthy that the EC (Jiang *et al.*, 2005) and TC (Jeng and Chen 2011) are two special cases of the proposed algorithm.

SIMULATION RESULTS

Fig 1. shows the Matlab simulation, PAPR v/s CCDF graph of a simple OFDM system employing BPSK and QPSK modulation techniques. From this graph it is observed that the PAPR is greater than 12dB. PAPR value for this system is quite large. OFDM signal consists of a lot of independent modulated subcarriers, which creates the problem of PAPR. It is impossible to send this high peak amplitude signals to the transmitter without reducing peaks. So we have to reduce high peak amplitude of the signals before transmitting.

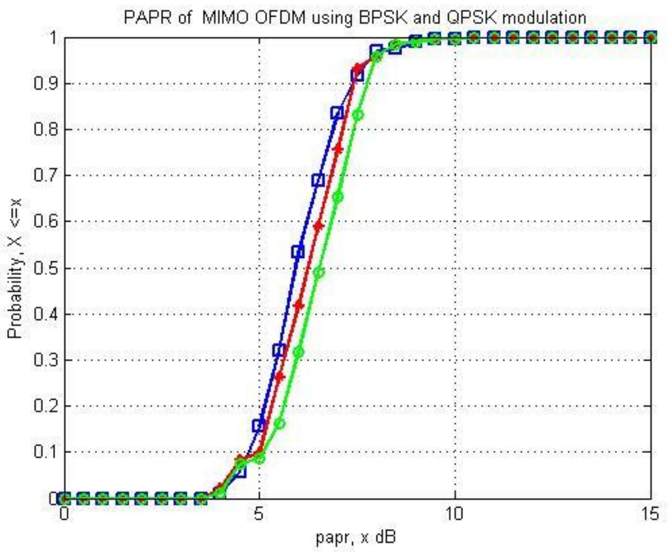

Figure 1. PAPR of OFDM using BPSK and QPSK modulation

Fig 2 shows that using MIMO OFDM the PAPR is 10.5 dB using QPSK modulation technique. This is 2 dB less than the PAPR of simple OFDM system as shown in fig1. This is the effect of MIMO-OFDM system. It is observed that in case of 8x8 MIMO OFDM system the effect of PAPR is also less as compared to a simple OFDM system. Now by using NCT, PAPR is further reduced which is shown in Fig 3.

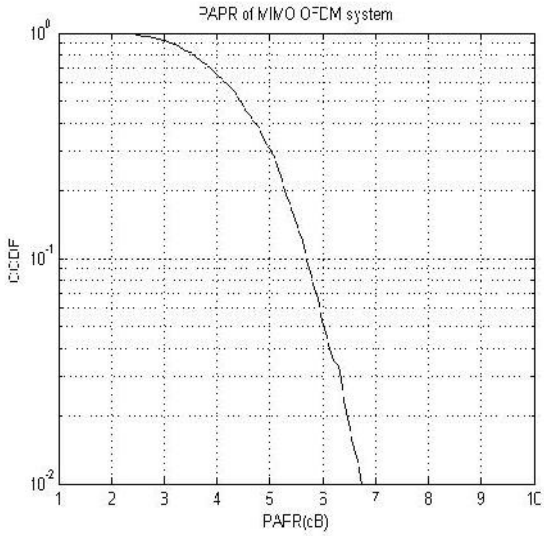

Figure 2. PAPR of MIMO OFDM system

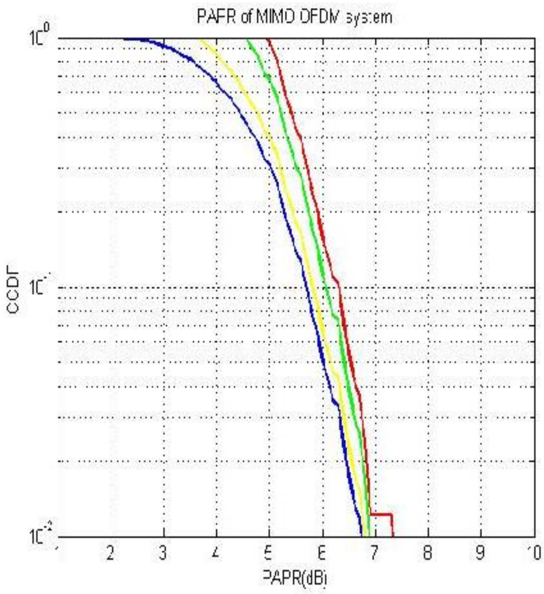

Figure 3. PAPR reduction of MIMO OFDM system using NCT

CONCLUSION

PAPR of MIMO-OFDM system and simple OFDM system is compared. It is shown that PAPR of high antenna configuration employing 8 antennas at the transmitter and receiver in MIMO-OFDM system is better than the PAPR of an OFDM system. Further, by using NCT for PAPR reduction, PAPR value is reduced up to a lower value of 3 dB compared to MIMO OFDM system with using NCT algorithm for PAPR reduction. Due to its simplicity and effectiveness, NCT is an attractive solution to reduce the PAPR of MIMO OFDM signal. In this paper, we investigate a new NCT algorithm which changes the statistics of original signal from the complex Gaussian to a desirable PDF defined as a linear piecewise function.

REFERENCES

Hou J., J. Ge,D. Zhai, and J. Li, "Peak-to-average power ratio reduction of OFDM signals with nonlinear companding scheme," *IEEE Trans. Broadcast.*, vol. 56, no. 2, pp. 258–262, Jun. 2010.

Hou, J. J. H. Ge, and J. Li, "Trapezoidal companding scheme for peak-to-average power ratio reduction of OFDM signals," *Electron. Lett.*, vol. 45, no. 25, pp. 1349–1351, Dec. 2009.

Huang X., J. Lu, J. Zheng, J. Chuang, and J. Gu, "Reduction of peaktoaverage power ratio of OFDM signals with companding transform," *IEE Elec. Lett.*, vol. 37, pp. 506–507, Apr. 2001.

Huang X., J. Lu, J.Zheng,K.B.Letaief, and J. Gu, "Companding transform for reduction in peak-to-average power ratio of OFDM signals," *IEEE Trans. Wireless Commun.*, vol. 3, no. 6, pp. 2030–2039, Nov. 2004.

Jaing T., W. Xiang, P. C. Richardson, D. Qu, and G. Zhu, "On the nonlinear companding transform for reduction in PAPR of MCM," *IEEE Trans. Wireless Commun.*, vol. 6, no. 6, pp. 2017–2021, Jun. 2007.

Jeng S. S. and J.M. Chen, "Efficient PAPR reduction in OFDM systems based on a companding technique with trapezium distribution," *IEEE Trans. Broadcast.*, vol. 57, no. 2, pp. 291–298, Jun. 2011.

Jiang T. and Y. Wu, "An overview: Peak-to-average power ratio reduction techniques for OFDM signals," *IEEE Trans. Broadcast.*, vol. 54, no. 2, pp. 257–268, Jun. 2008.

Jiang T., Y. Yang, and Y. Song, "Exponential companding transform for PAPR reduction in OFDM systems," *IEEE Trans. Broadcast.*, vol. 51, no. 2, pp. 244–248, June 2005.

Kabir W., "Orthogonal Frequency Division Multiplexing (OFDM)," *Microwave Conference*, pp.178-184, 2008.

Krenik, B. "4G wireless technology: When will it happen? What does it offer?,", *IEEE Asian Solid-State Circuits Conference*, pp.141-144, 2008.

Soma P., D.S Baum; V. Erceg; R. Krishnamoorthy; A.J. Paulraj, "Analysis and modeling of multiple-input multiple-output (MIMO) radio channel based on outdoor measurements conducted at 2.5 GHz for fixed BWA applications,"*IEEE International Conference on Communications*, vol.1, pp.272-276, 2002.

Stuber G.L., J.R Barry; S.W McLaughlin; Ye Li; M.A Ingram; T.G Pratt, "Broadband MIMO-OFDM wireless communications," *Proceedings of the IEEE* , vol.92, no.2, pp.271-294, 2004.

Tao Jiang; Yiyan Wu, "An Overview: Peak-to-Average Power Ratio Reduction Techniques for OFDM Signals," *IEEE Transactions on Broadcasting*, vol.54, no.2, pp.257-268, 2008.

Wang X. B., T. T. Tjhung, and C. S. Ng, "Reduction of peak-to-average power ratio of OFDM system using a companding technique," *IEEE Trans. Broadcast.*, vol. 45, no. 3, pp. 303–307, Sep. 1999.

Yang G., Y. Zhou, and S. Qian, "Using hyperbolic tangent sigmoid transfer function for companding transform in OFDM system," in *International Symposium on Communications and Information Technologies, ISCIT '07*, Oct. 2007, pp. 87–90.

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