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Reduction of PAPR and Efficient Detection Ordering Scheme for MIMO Transmission Systems Using Power Control

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Abstract:

The technical challenges for communication engineers is the development of best performance wireless networks with negligible amount of distortions. We have to consider multipath propagation attenuation and radio spectrum inefficiency. Now a days, In MIMO(Multi Input Multi Output) systems there is a huge demand for the networks with the high transmission rates and better quality of service which are having low PAPR ratio.Instead of OFDMA,filter banks are used in massive MIMO to reduce the complexity.But they are error prone to noise.This base paper discusses about PAPR reduction in MIMO systems using different precoding based OFDM systems. Mainly, minimization of multi-antenna systems by controlling the transmission power and reduction of PAPR using ZC(Zadoff-Chu) matrix transform.

keywords:

OFDM,Peak-to-average power ratio

I.Introduction:

Filter banks used in massive MIMO to reduce the complexity are error prone to noise[1].MIMO can be implemented efficiently using OFDM[2].Due to the robustness against narrowband interference, good spectral efficiency, improved sevice quality and frequency selective fading, OFDM became the technology of choice in wired and wireless digital communication systems for the next generation [4]. OFDM stands for Orthogonal Frequency Division Multiplexing. It is a multicarrier transmission scheme. By using a Cyclic Prefix(CP),a Guard interval(GI) is inserted so that OFDM can withstand to Inter symbol interference. Using a simple equalizer OFDM moderates the frequency selectivity of the multipath channel[5]. Asymmetric digital subscriber line(ADSL) uses OFDM technology. In various communication standards like DVB(Digital Video Broadcasting), DAD(Digital Audio Broadcasting) and even in the networks beyond 3G .

The biggest disadvantage in Orthogonal Frequency Division Multiplexed signal is the peak-to-average power ratio[3]. In the literature many number of reduction techniques for PAPR have been proposed. [7]- [12]. However, precoding techniques are simple linear techniqus because they does not require any additional information. This paper consists the presentatation of a PAPR reduction using the ZCT-ROFDM (Zadoff-Chumatrix Transform Rowwise precoder based OFDM) system with RRC(Root Raised Cosine) pulse shaping and comparision with other precoding based OFDM systems. The efficient detection ordering scheme for multi input- multi output transmission systems using power control is proposed and verified using Matlab and the results are analyzed.The remaining portions of this paper are categorized as follows: the description of section II is basics of OFDM ,PAR or PAPR, and ZCT method.System model,ZCT precoded OFDM (ZCT-OFDM) system[11] and ordering scheme are presented in section III and simulation results are presented in section IV and conclusion of the paper is presented in section V.

II.OFDM & ZCT:

Because of their great potential of enhancing the system's performance, The utilization of MIMO (multiple-input multiple-output) systems became an active area of research as well as practical transceiver implementations for.

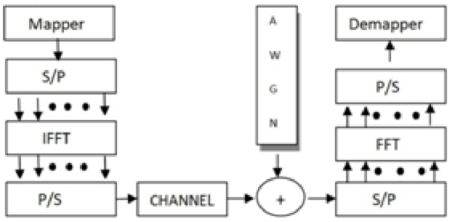


Fig 1: A conventional OFDM system.

The block diagram of conventional OFDM system is showned in fig(1).The input to the serial to parallel converter is the baseband modulated symbols from mapper.

It generates a complex vector of size N.It is written as X=[X0,X1,X2,.......XN-1]T .Then it is passed through IFFFT block to generate complex baseband OFDM signal which has N subcarriers.It is given by

$$X_n = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_{k.}\, e^{j2\pi \frac{n}{N} k} \quad \dots \dots \quad \text{Eq(1)}$$

Where n=0,1,2…..N-1

The PAPR for the above system can be defined as follows

$$\text{PAPR} = \frac{\max\,[|x_n|^2]}{E\,[|x_n|^2]} \quad \text{Eq-(2)}$$

Where E [.] indicates the expectation. It helps in band radiation. By filling ZCT kernel row-wise or alternatively column wise, the ZCTs are obtained from ZC(Zadoff-Chu) sequences . Column wise filling give rise 7.8 dB at clip rate of 10-3 while Row-wise filling gives rise to CE-OFDM (Constant Envelope OFDM) system with 0 dB PAPR, with system subcarriers for QPSK modulation or any modulation depending upon the type of communication.Constant Envelope OFDM (orthogonal frequency division multiplexing) systems helps to keep in band radiation with the help of pulse shaping and the PAPR are not a constant zero db .In this paper we show PAPR analysis of several pre-coding based OFDM techniques with the popular Rout Raised Cosine(RRC) pulse shaping. The simulation results shows that ZCT row wise pre-coder OFDM(ZCT-R-OFDM) system has lowered PAPR then the ZCT Column-wise pre-coder based

OFDM (ZCT-C-OFDM)system, the hardward transform pre-coder based OFDM (WHT-OFDM) systems and the conventional OFDM systems. We can derive the ordering of the system from the convexity of the function. From the ordering of the system we can get converge to the geometric mean. The use of the geometric mean is to maintain the constant threshold, and also ordering of the algorithm is derived from the geometric mean. For this modified scheme of employing adaptive threshold technique is developed by correlation among the ordering result. The simultaneous results are obtained by the theoretical analysis. QR-decomposition not only require reduced computational complexity when we compared to the conventional scheme. Due to this error performance is improved in result.

III.SYSTEM MODEL:

A.ZC Sequences and ZCT (Zadoff-chu Matrix Transform):

ZC (Zadoff-Chu) sequences have optimum correlation properties. They are class of poly phase sequences. ZC sequences have constant magnitude and an ideal periodic auto-correlation. According to [13], ZC sequences of length N can be defined as

$$a_n = \begin{cases} e^{\frac{j2\pi r}{N}\left(\frac{k(k+1)}{2}+qk\right)} & for\ N\ Odd \\ e^{\frac{j2\pi r}{N}\left(\frac{k^2}{2}+qk\right)} & for\ N\ Even \end{cases} \quad \dots .3$$

where k = 0, 1, 2… N-1, q is any integer, r is any integer relatively prime to N and j=√-1. The kernel of the ZCT is defined in eqn(4),is obtained by reshaping the ZC sequence by k=mL+l as hereunder.

$$A = \begin{bmatrix} a_{00} & a_{01}\cdot\cdot & .\,a_{0L-1} \\ a_{10} & a_{11}\cdot\cdot & .\,a_{1L-1} \\ \vdots & & \vdots \\ a_{(L-1)0} & a_{(L-1)1}\cdot\cdot & a_{(L-1)(L-1)} \end{bmatrix} \dots 4$$

Here l is the column variable and m is the row variable. In other words N=L2 point long ZC sequence fills the kernel of the matrix rowwise.In this case PAPR reduces to 0dB[10].However the PAPR reduces to 7.8dB,it does not reduces to 0dB,if the kernel is filled columnwise[7].

B.OFDM system with ZCT precoding:

ZCT precoded OFDM system is showned in fig(2). Here,The ZCT kernel acts as a rowwise precoding matrix of A of dimensions N=L×L and it is applied to each symbol to reduce PAPR.The baseband modulated data is passed through S/P converter in the ZCT precoded OFDM system which generates a complex vector of size L. The complex vector can be written as

X= [X0, X1, …XL-1]T.

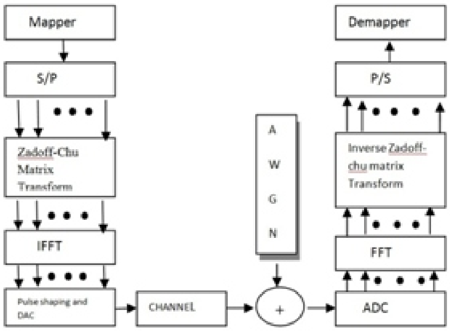


Fig 2: A ZCT precoded OFDM System

After that Zadoff Chu matrix transform precoding is applied to complex vector X.This precoding technique transforms the complex vector into a new vector with same length L.The new vector obtained by ZCT precoding with lenth L can be written as Y=AX=[Y0,Y1,Y2,.......YL-1]T Where A is a precoder matrix of size L×L and y_m can be written as

$$Y_m=\sum_{l=0}^{L-1} a_{m,l}.X_l \quad ,m = 0,1,..L-1......(5)$$

Here $a_{m,l}$ indicates mth row and lth column.

The ZCT-R-OFDM complex baseband signal with L subcarriers is defined as

$$x_n = \frac{1}{\sqrt{L}}\sum_{m=0}^{L-1} Y_m.\, e^{j2\pi\frac{n}{L}m},..................(6)$$

where $n = 0,1,.....L\text{-}1$

After RRC (Root Raised Cosine) pulse shaping and D/A of n Samples, the complex pass band transmit signal x(t) of ZCT-R-OFDM can be written as

$$x(t)=e^{jw_ct}\sum_{n=0}^{L-1} x_n\,.\,r(t-n\breve{T})......(7)$$

Here ω_c is the carrier frequency, r (t) is the baseband pulse and $\breve{T}$ =after IFFT, compressed symbol duration in seconds.

The definition of Root Raised Cosine filter is

$$r(t) = \frac{\sin(\frac{\pi t}{T}(1-\alpha))+4\alpha\frac{t}{T}\cos(\frac{\pi t}{T}(1+\alpha))}{\frac{\pi t}{T}(1-\frac{16\alpha^2t^2}{T^2})}..(8)$$

With pulse shaping the PAPR of the ZCT-R-OFDM is defined as

With pulse shaping the PAPR of the ZCT-R-OFDM is defined as

$$PAPR=\frac{\max_{0\le t\le NT}\left[|x(t)|^2\right]}{\frac{1}{NT}\int_0^{NT}\left[|x(t)|^2\right]dt}.........(9)$$

Without pulse shaping PAPR of ZCT-R-OFDM can be defined as

$$PAPR=\frac{\max_{n=0,1..,N-1}\left[|x_n|^2\right]}{\frac{1}{M}\sum_{n=0}^{N-1}\left[|x_n|^2\right]}......(10)$$

Assume that the number of transmit antennas is N_t and the number of receiving antennas is N_r in MIMO system. TheN_rXN_T matrix H with the elementh_{ji} represents flat-fading MIMO channel. h_{ji} Represents the channel gain from ith transmit antenna to jth receive antenna. The N_rX1 signal vector received $Y = [y1,...,y_{Nr}]^T$is written as

$$y = \sqrt{\frac{E_s}{N_t}}\,HP_x + n \quad ----- (11)$$

Where $X = [\,x1 ...,x_{Nr}]^T$ denotes N_tX1 the transmittedsignal vector, and $n = [n1,....,n_{N_r}\,]^T$ is the one–dimensional noise vector. In noise vector the elements follow complex zero mean Gaussian distribution with variance of σ_n^2 . E_s is the total transmitted signal energy on transmit antennas and $P = \sqrt{N_t}$,diag(P_1,$P_{2,}$,....P_{N_t})

Denotes the diagonal PA precoding matrix.

An $(N_r+N_t)X\,N_t$ augmented channel matrix $\overline{H}$, $(N_r+N_t)X\,1$ an extended receive vector $\bar{y}$ and $N_tX\,1$ an zero matrix $0_{N_{t,1}}$,to express the signal model for the MMSE-QR detector, is given by.

$$\bar{H} =\begin{bmatrix} H \\ \sigma_n I_{N_t}\end{bmatrix}\xrightarrow{ordering}\ \bar{Q}\,\bar{R}\ and\ \bar{y} = \begin{bmatrix} y \\ 0_{N_t,1}\end{bmatrix}\ --(12)$$

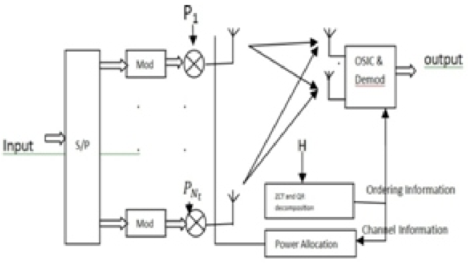


Fig 3: MIMO Transmission model with QR OSIC and ZCT Decoder

The detection-order defines the upper triangular matrixR ¯differently which determines the post detection SINR ρ_k and SNR of the data stream is given as

$$\rho_k = \frac{E_s}{\sigma_n^2} \; P_k^2 \; \overline{R_{k,k}^2} \; - 1 \,, \quad k= 1,2,\ldots,N_t \ldots(13)$$

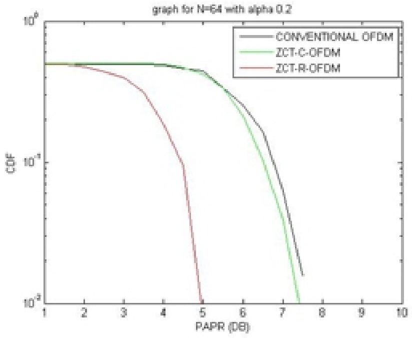
Using the architecture shown in Fig.3 ,The BER-minimized PA transmission using QR-decomposition based ZCT-OSIC detection can be performed. Transmission power Pk is assigned to each data stream based on the feedback information of the diagonal elementsR ̄_(k,k). Through a diagonal PA matrix, the independently encoded symbols are processed and then they are transmitted from Nt data streams. According to the designated detection-order, The QR-OSIC receiver detects the transmit symbols sequentially.

TABLE 1:Proposed Detection Ordering Algorithm

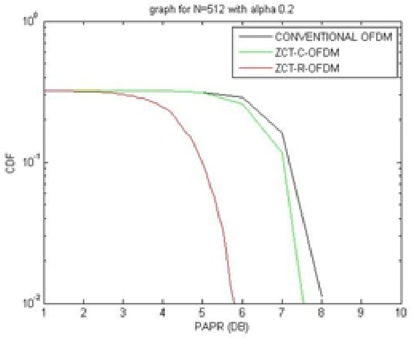
Step	Operation for each step
1.	$\bar{R} \equiv 0_{N_t}, \bar{Q} \equiv \bar{H}$,k={1,2,3....N_t }, $\mu_1 = \mu$
2.	For i=1,2,3...N_t
3.	$\tau_i = \lVert \bar{Q}_{:,i} \rVert^2$
4.	End
5.	For l=1,2,3...N_t
6.	$K_l = \arg \overset{min}{\omega} \left\lvert \sqrt{\tau_\omega} - \mu_l \right\rvert$
7.	Fixed : $\mu_{l+1} = \mu_l$, Adaptive: $\mu_{l+1} = \sqrt[\frac{N_{t-l+1}}{N_{t-l}}]{\frac{\mu_l}{\bar{R}_{l,l}^{N_{t-l+1}}}}$
8.	$\bar{R}_{(:,l)} \longleftrightarrow \bar{R}_{(:,k_t)}, \tau_l \longleftrightarrow \tau_{k,l}$ K(l) $\longleftrightarrow$ k(k_l), $\bar{Q}_{(1:N_r-l+1,t)} \longleftrightarrow$ $\bar{Q}_{(1:N_r-l+1,k_l)}$
9.	$\bar{R}_{(l,l)} = \sqrt{\tau_l}$
10.	$\bar{Q}_{(:,l)} = \frac{\bar{Q}_{(:,l)}}{\bar{R}_{(l,l)}}$
11	For m= l+1,.....N_t
12.	$\bar{R}_{(l,m)} = \bar{Q}^H_{(:,l)} \cdot \bar{Q}_{(:,m)}$
13.	$\bar{Q}_{(:,m)} = \bar{Q}_{(:,m)} - \bar{R}_{(l,m)} \cdot \bar{Q}_{(:,l)}$
14.	$\tau_m = \tau_m - \bar{R}^2_{(l,m)}$
15.	End
16.	End

IV. Simulation Results:

In order to show the simulation results for PAPR analysis using ZCT-R-OFDM with RRC pulse shaping,input is randomly generated and then modulated by Quadrature phase shift keying(QPSK).All the simulation results are performed based on 105 random OFDM blocks.
parameters of system:
1.system subcarriers:64,512
2.precoding techniques:WHT,ZCT
3.modulation technique:QPSK
4.Pulse shaping:RRC
5.Rolloff factor α for RRC:α=0.22
6.Oversampling factor=4
PAPR is evaluated stastically using complementary cumulative distributive function.The probability of PAPR exceeding the given threshold is
CCDF=Prob(PAPR>PAPRO)



Result of ZCT over other conventional PAPR techniques with N=64,512 with alpha 0.2



It is clear from the simulation results that the PAPR value of ZCT-R-OFDM is less when compared to other PAPR techniques even when the N value is increased/Decreased.

V. CONCLUSION:

In this paper, we present a PAPR reduction using the ZCT-R-OFDM system for MIMO transmission with Root raised cosine pulse shaping. From the results and series of experiments conducted,we conclude that ZCT proves to be a better model among the other pre-coding techniques like WHT etc..in terms of PAPR. Another noticable fact is that,pulse shaping increases the PAPR of the ZCT-R-OFDM from 0dB to 5dB. Any power increase and complex optimization is not required in ZCT-R-OFDM system and no need to send any additional information to the receiver. In addition, this system offer substantial performance gain in fading multipath channels.It is sufficient to confirm the superiority of the proposed design because the ordering algorithm of previous studies comply with the stategy of the B-OSIC(Ordered Successive Inerference Cancellation)[14]-[16].It also take advantage of the frequency variations of the communication channel and Performing ZCT-QR decomposition based OSIC detection made it more eligible for transmission.

REFERENCES:

[1] Arman Farhang*,’Nichola Marchetti*,Linda E.Dolye and Farhang Boroujeny,’Filter bank Multicarrier for Massive MIMO’,feb 2014.

[2] Hong-Jie Chou, “PAPR Reduction Techniques with Hybrid SLM-PTS Schemes for OFDM Systems.” IEEE Trans.Consumer Electronics, vol.1,978-990,Dec 2012.

[3]J.Hoydis,S.Ten Brick and M.Debbah,’Massive MIMO in the UL/DL of cellular networks:How many antennas do we need’,IEEE journal on selected areas of communications,vol31,no.2.pp.160-171,2013.

[4] Y. Wu and Z. Y. William, “Orthogonal frequency division multiplexing: A multi-carrier modulation scheme,” IEEE Trans. Consumer Electronics, vol. 41, no. 3, pp. 392–399, Aug. 1995.

[5] B. Muquet, Z. Wang, G. B. Giannakis, M. Courville, and P.Duhamel, “Cyclic prefixing or zero padding for wireless multicarriertransmissions,” IEEE Trans. Comm., vol. 50, pp. 2136-2148, Dec.2002.

[6] R. V Nee and A. Wild, “Reducing the Peak-To-Average Power Ratioof OFDM,” 48th IEEE Vehicular Technology Conference, VTC98, vol.3, 18-21 May 1998.

[7] Y. Kuan Min and V. Jeoti, “A Novel Signal Independent Techniquefor PAPR Reduction in OFDM Systems”, International Conference onSignal processing, communication and networking (IEEE-ICSCN2007), 22-24 Feb. 2007.

[8] I. Baig and V. Jeoti, “PAPR Analysis of DHT-Precoded OFDMSystem for M-QAM”, the 3rd International Conference on Intelligentand Advanced Systems (ICIAS2010), June 2010.

[9] Y. Tasi, G. Zhang, and X. Wang, “Orthogonal Polyphase Codes forConstant Envelope OFDM-CDMA System,” IEEE, WCNC, pp. 1396– 1401, 3-6 April 2006.

[10] S. C. Thompson, A. U. Ahmed, J. G. Proakis, J. R. Zeidler, and M. J.Geile, “Constant envelope OFDM,” IEEE Trans. Communications,vol. 56, pp. 1300-1312, Aug. 2008.

[11] I. Baig and V. Jeoti,” PAPR Reduction in OFDM Systems: Zadoff-Chu Matrix Transform Based Pre/Post-Coding echniques”, 2ndInternational Conference on Computational IntelligenceCommunication Systems and Networks (CICSyN 2010), 28-30 July2010.

[12] V. Jeoti and I. Baig, “A Novel Zadoff-Chu Precoder Based SLM Technique for PAPR Reduction in OFDM Systems”, invited paper, Proceedings of 2009 IEEE International Conference on Antennas,Propagation and Systems (INAS 2009), 3-5 Dec. 2009.

[13] I. Baig and V. Jeoti, “DCT Precoded SLM Technique for PAPR

[14]J.Benesety,Y.Huang,and J.Chen,”A fast recursive algorithm for optimum sequential signal detection in a BLAST system”,IEEE Trans.signal process,vol.51. no.7.pp.1722-1730,july 2003

[15]Z.Yan,K.V.Wong,and Z.Q.Luo,”Optimal diagonal precoder for multiantenna communication systems”, IEEE Trans.signal process,vol.53.no.6.pp.180-187,jan. 2007.

[16]N.Wang,S.D.Blostein,”Approximate minimum BER power allocation for MIMO spatial multiplexing systems”. IEEE Trans.column,vol55,no.1,pp.180-187,jan 2007