Performance Analysis of PAPR reduction for MIMO OFDM using PTS, RNS and DHT

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Abstract- In wireless communication systems, multi input multi output orthogonal frequency division multiplexing (MIMO-OFDM) systems plays an important role. Orthogonal Frequency Division Multiplexing (OFDM) is an efficient modulation technique that splits a single wideband signal into various narrowband independent signals. It is used in digital audio and video broadcasting, wireless LAN/MAN standards, and Wi MAX standards. However, one of the serious problems of OFDM is the high Peak to Average Power Ratio (PAPR), which causes a signal distortion at the High Power Amplifier (HPA) of a transmitter. MIMO-OFDM system have peak to average power ratio (PAPR). Which is a major challenges for multicarrier transmissions i.e. OFDM based systems. To reduce the nonlinear distortion, the power efficiency of the HPA has to be significantly decreased. In this paper, the proposed scheme reduces the PAPR by the use of Discrete Hartley Transform (DHT) based PAPR reduction technique in MIMO-OFDM system. The Discrete Hartley transform allow a function to be broke into two independent sets of sinusoidal components; these sets are represented in terms of positive and negative frequency components, respectively. This verify the use of the properties of the DHT cas operation to effectively and efficiently reduction of PAPR.The proposed DHT based PAPR reduction scheme in MIMO-OFDM, is compared with the partial transmit sequence (PTS), and Residue number system (RNS) for PAPR reduction and is verified by MATLAB simulation.

Keyword: peak to average power ratio (PAPR), partial transmit sequence (PTS), Selective mapping (SLM), Residue number system (RNS), Complementary Cumulative Distribution Function (CCDF), DHT (Discrete Hartley Transform).

I. INTRODUCTION

Today's, there are many PAPR reduction technologies, such as peak windowing, clipping, companding transform etc but all those having some limitations. It is found that the nonlinear distortion and clipping of transmitted signals are responsible for system's performance degradation.

Recently many errorless technologies of PAPR reduction have been invented and described. One of them is Partial Transmit Sequence (PTS) scheme [3], which proves an efficient approach and a errorless scheme for PAPR reduction by efficiently combining signal sub-blocks. Another method is Selective Mapping (SLM) [22], is also a good PAPR reduction technology, which produces some statistically independent sequences from the same data and sequences with the lowest PAPR is transmitted. The above two schemes are responsible for improvement of PAPR statistic but both have additional complexity and loss of data rate. This is happen because they need to some extra IFFT and iterations of phase optimization and transmit the side information and also at the same level of PAPR reduction. The SLM scheme has higher computational complexity because SLM operates on all carriers.

For minimizing the computational complexity of above PTS and SLM technique, a new scheme has been proposed Residue number system (RNS). Residue number system is a parallel number system and it uses the properties of Chinese remainder theorem (CRT). The Chinese remainder theorem breaks the large integer into independent and parallel smaller ones with a specific modulus set. RNS simplifies the computations by dividing a problem into a set of parallel and independent residue computations because RNS have carry free and parallel properties. Now days the RNS attracts more attention in parallel communication field because the RNS have parallel and fault-tolerant properties. An RNS based transmission for OFDM was proposed in “RNS based OFDM transmission scheme with low PAPR,” which gives description about RNS based OFDM systems [5].

In this proposed work PAPR reduction is done by using Discrete Hartley transform (DHT) in MIMO OFDM. The Discrete Hartley transform permits a function to be decomposed into two independent sets of sinusoidal components; these sets are represented in terms of positive and negative frequency components, respectively. This verify the use of the properties of the DHT cas operation to effectively and efficiently reduction of PAPR. The Hartley transform is an integral transformation that maps a real-valued temporal or spacial function into a real-valued frequency function via the kernel, $\mathrm{cas}(\nu x) \equiv \cos(\nu x) + \sin(\nu x)$. This novel symmetrical formulation of the traditional Fourier transform, attributed to Ralph Vinton Lyon Hartley in 1942 [Kraig J. Olejniczak University of Arkansas, chapter no 4 The Hartley Transform] leads to a parallelism that exists between the function of the original variable and that of its transform. Furthermore, the Hartley transform permits a function to be decomposed into two independent sets of sinusoidal components; these sets are represented in terms of positive and negative frequency components, respectively.

This is in contrast to the complex exponential, exp($j\omega x$), used in classical Fourier analysis. For periodic power signals, various mathematical forms of the familiar Fourier series come to mind. For aperiodic energy and power signals of either finite or infinite duration, the Fourier integral can be used. In either case, signal and systems analysis and design in the frequency domain using the Hartley transform may be deserving of increased awareness due necessarily to the existence of a fast algorithm that can substantially lessen the computational burden when compared to the classical complex-valued Fast Fourier Transform (FFT) and so discrete Hartley transform (DHT) can be used in reduction of PAPR in OFDM systems.

II. SYSTEM MODEL

MIMO OFDM system on DHT based

The MIMO OFDM system model was illustrated inin Fig. 1. The inverse (forward) fast Hartley transform

(FHT) implements the OFDM modulation (demodulation). Since the DHT is a real transform, if a real constellation is used for the input data mapping, the discrete OFDM signal

$$H_k=\sum_{n=0}^{n-1} x_n \left[\cos\left(\frac{2\pi}{N}nk\right)+\sin\left(\frac{2\pi}{N}nk\right)\right] \quad k=0\ldots\ldots N-1$$

$$H(w)=\frac{1}{2\pi}\int_{-\infty}^{\infty} x(t).cas(wt)d$$

$$Cas(t) = \cos(t)+\sin(t) = \sqrt{2}\sin\left(t+\frac{\pi}{4}\right) + \sqrt{2}\cos\left(t-\frac{\pi}{4}\right)$$

is real; $x(n)$ is the n-th element of the N-length vector of constellation symbols at the input of the IFHT and N is the transform order.

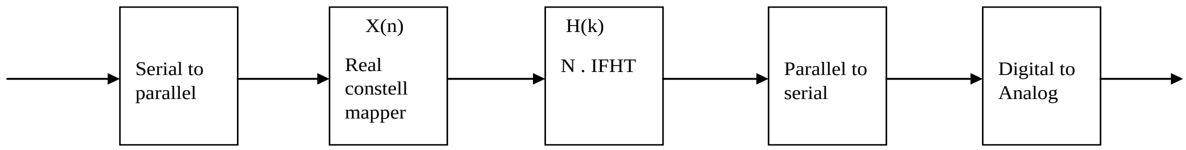

Figure 1 block diagram of DHT based Transmitter of MIMO OFDM system

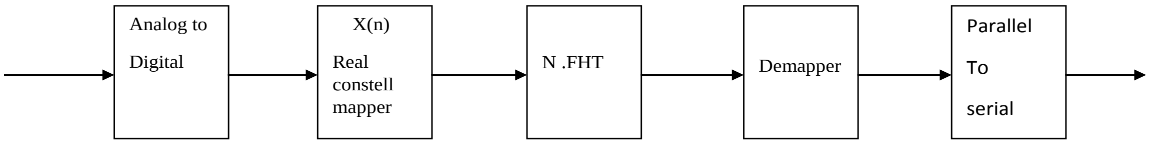

Figure 2 block diagram of DHT based Receiver of MIMO OFDM system.

III. PREVIOUS WORK

A. Analysis of PAPR for MIMO-OFDM

As definition, the PAPR is the ratio between the maximum peak power and the average power for output signals at each antenna.

$$PAPR_{n_t} = 10\ log\frac{\max\left\{\left|S_{n_t,k}\right|^2\right\}}{E\left\{\left|S_{n_t,k}\right|^2\right\}}(dB)$$

$$(n_t = 1, 2\ldots\ldots N_T;\ k = 0, 1, 2\ldots\ldots N-1) \quad (1)$$

When we consider for MIMO-OFDM, the PAPR of every N_T transmit signals should be as small as possible at the same time and this is described as-

$$PAPR = \max\{PAPR_1, PAPR_2\ldots\ldots\ldots PAPR_{N_T}\} \quad (2)$$

We know about the Complementary Cumulative Distribution Function (CCDF), which is generally used to notify the probability criteria. For conventional OFDM as shown in equation (3), the PAPR exceeds a given value z.

$$P\{PAPR > z\} = 1-\{PAPR \le z\} = 1-(1-e^{-z})^N \quad (3)$$

For MIMO-OFDM, the CCDF is presented for N_T number of antennas as-

$$P\{PAPR > z\} = 1-\{PAPR \le z\} = 1-(1-e^{-z})^{N_T N} \quad (4)$$

In case of MIMO-OFDM, from equation (3) & (4), we can observe that the PAPR performance is very poor in comparison to OFDM systems.

B. Analysis of Partial Transmit Sequence (PTS) in MIMO-OFDM[3]

From figure 1, each antenna channel is a single antenna PTS-OFDM and there are partitions of input data block of N symbols into M separated sub-blocks which is given as-

$$X = [X^0, X^1 \dots\dots\dots X^{M-1}]^T \qquad (5)$$

Then each separated sub-block is integrated by a complex phase factor $b^\mu = e^{j\varphi\mu}$, $\mu = 1, 2 \dots\dots\dots M$, taking its IFFT to found-

$$x = IFFT\{\sum_{\mu=1}^{M} b^\mu X^\mu\} = \sum_{\mu=1}^{M} b^\mu x^\mu \qquad (6)$$

The optimal phase factor b^μ can be found after the PAPR comparisons among the sequences. For lower PAPR in the n_t antenna, the corresponding signal can be denoted as-

$$S^{\sim}_{n_t,k} = \sum_{\mu=1}^{M} b^\mu , 0 \le k \le N-1, 1 \le n_t \le N_T \qquad (7)$$

Here x^μ is known as partial transmit sequence. The PAPR vector is selected such that PAPR can be minimized.

For μ sub block and W phase factors $w^{\mu-1}$sets of phase factors needs to be searched to find optimum phase factor which reduces PAPR.

In PTS technique we are also transmitting side information as phase sequence which minimizes the PAPR .therefore search complexity increases with more number of sub blocks.

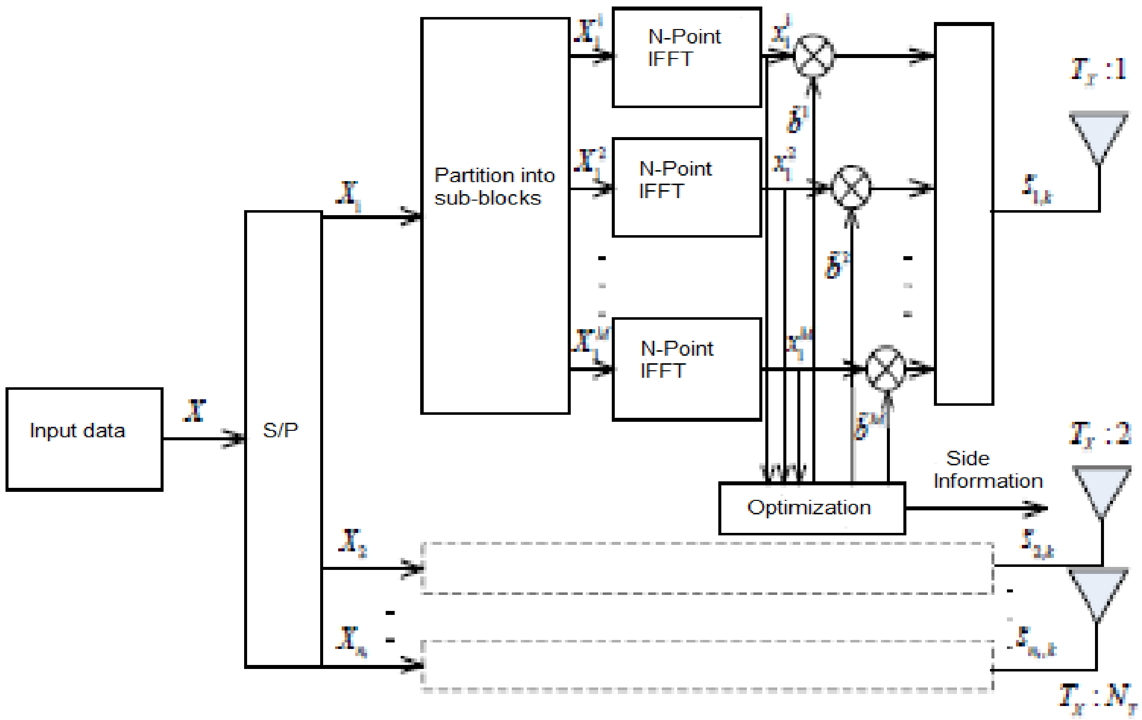

Figure1: The block diagram of PTS scheme in MIMO-OFDM.

C. Analysis of Residue number system (RNS) [5]

The residue number system is always described by relative prime modulus set $m_v (v = 1,2 \dots\dots\dots V)$. In RNS, any integer R can be expressed by residue sequence $\{r_1, r_2 \dots\dots\dots r_v\}$ and-

$$r_v \equiv R(mod\ m_v) \qquad (8)$$

The number r_v is stated as residue of R with respect to m_v and generally it is denoted by $r_v = \langle R \rangle_{m_v}$. By this idea, a large integer can be divided into the small residues and so the resulted residues are always smaller than the corresponding modulus. The integers in this residue number system are in the range of [0, M_I] and this should be denoted separately and clearly. Here,$M_I = \prod_{i=1}^{V} m_v$, It indicates dynamic range or legitimate range of the numbers and symbols (information symbols). The information symbols can be easily and uniquely collected with the help of residue sequence and CRT, which is one of the basic theorems of residue number system. The information symbols R and its residues are related as-

$$R = \left(\sum_v^V S_v \left|\langle 1/S_v\rangle_{m_v}\right| r_v\right) mod\ M_I \qquad (9)$$

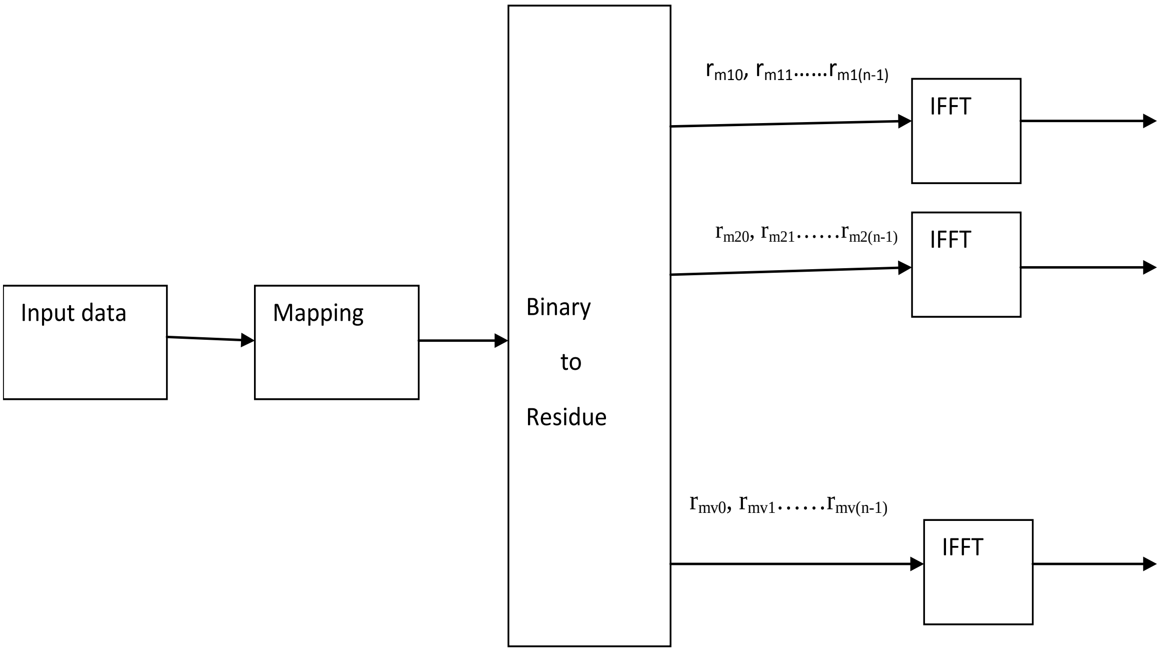

Figure.2: Block diagram of RNS-based scheme in MIMO-OFDM.

For MIMO-OFDM, the block diagram of RNS-based peak to average power ratio reduction scheme is given in figure 2. Here the number of modulus $\{m_1, m_2 \dots\dots\dots m_v\}$ is V and the inputs data are transformed into V residues through corresponding modulus set. The numbers of residue sub-channels are according to the number of transmit antennas. The OFDM modulation is performed by these residue signals in the corresponding residue channels. Single IFFT of length N is applied in every of the V number parallel residue sub channels.

The detail function of mapping module is, when the input is positive, this is send into binary to residue (B/R) module directly and in another case the input adds the legitimate M_I before binary to residue module. The serial data signals are break into V number parallel residue sub channels transmitting signals by binary to residue conversion, which is stated in equation (8).

The residue sequences $\{r_{m_v0}, r_{m_v1} \dots\dots\dots r_{m_v(N-1)}\}$, which is related to the modulus m_v residue sub channel in every residue sub channel, are transmitted into IFFT module. The output of modulus m_v residue sub channel is expressed as following equation after IFFT.

$$S_{m_v,k} = S(kT/N) = \sum_{i=0}^{N-1} r_{m_v,i} \exp(j\frac{2\pi ik}{N})$$

$$(0 \le k \le N-1, 0 \le i \le N-1) \qquad (10)$$

According to central limit theorem, for big subcarriers, both parts real and imaginary of OFDM signals have asymptotically Gaussian distribution. In each sub channel, the peak to average power ratio can be written as follows for RNS based scheme.

$$PAPR_{n_t} = 10log\frac{\max\left\{\left|\sum_{i=0}^{N-1} r_{m_v,i}\exp(j\frac{2\pi ik}{N}\right|^2\right\}}{E\left\{\left|\sum_{i=0}^{N-1} r_{m_v,i}\exp(j\frac{2\pi ik}{N}\right|^2\right\}}$$

$$= 10log\frac{\max\left\{\left|\sum_{i=0}^{N-1} r_{m_v,i}\exp\left(j\frac{2\pi ik}{N}\right)\right|^2\right\}}{2\sigma^2}(dB) \quad (11)$$

Here σ is the variance of signal.

When we consider about MIMO-OFDM, the PAPR performance is worst and it can be seen by-

$$PAPR_{rns-mimo} = \max PAPR_{n_t}$$

Where n_t=1, 2……..N_T

$$= 10log\frac{max_{n_t}\left\{\left|\sum_{i=0}^{N-1} r_{m_v,i}\exp(j\frac{2\pi ik}{N})\right|^2\right\}}{2\sigma^2}(dB) \quad (12)$$

We have seen in equation (8) that the residue is always smaller with respect to corresponding modulus and it may be selected smaller in comparison to original number. In this case the residue becomes smaller than the original number. After processing through a rotation factor and adding all N elements, the residue still smaller than the sum of original one. So using RNS based reduction technique, we can reduce the PAPR and improve the overall performance of MIMO-OFDM systems.

IV. PROPOSED METHODOLOGY

Analysis of DHT based scheme

A multicarrier OFDM signal is the addition of many independent non constant envelope signals modulated onto subchannels of equal bandwidth. The data symbols *Xn*, is denoted as a vector X = [X0, X1, ... , XN–1]T that will be data block. The complex representation of a multicarrier signal consisting of N subcarriers is given by

$$X(t)=\frac{1}{\sqrt{N}}\sum_{n=0}^{N-1} X_n \quad e^{j2\pi n\Delta ft} \quad ,0\leq t\leq NT$$

Where, Δf represents subchannel spacing.

The PAPR of the transmitted IDHT symbols is written as

$$PAPR=\frac{\max\ 0\leq t\leq NT\,|x(t)|^2}{\frac{1}{NT}\int_0^{NT}|x(t)|^2\,dt}$$

The Complementary Cumulative Distribution Function (CCDF) is the most frequently used performance metric for PAPR reduction techniques. The CCDF of the PAPR indicates the probability that the PAPR of a OFDM signal exceeds a given PAPR threshold.

The CCDF of the PAPR of a data block is derived as

Pr(PAPR >Z) = 1 – Pr(PAPR ≤ Z)

= 1 – F(Z)N

= 1 – (1 – exp(–Z))N (8)

Where, Z is the PAPR threshold. Thus by using DHT scheme we can reduce PAPR of OFDM systems efficiently.

V. SIMULATION EXPERIMENT RESULT

The performance of PAPR reduction is evaluated by CCDF.

Parameters	value
Subcarrier number, N	2048
The number of input symbol s	1000
Antenna number, N_t	3
Modulations format	64QAM/4QAM
Modduli number of RNS, V	3
Moduli Set of RNS	{128,127,63}
PTS sub block number	3/8
PTS phase factor	{1, −1}

To compare with the original PTS scheme in MIMO-OFDM, we assume the antenna number of two schemes and the subcarrier number in each sub-channel are the same. Each OFDM symbol contains *N* = 2048 subcarriers throughout, where the number of input symbols is 1000. The parameter used for simulation is shown in Table I.

VI. SIMULATION RESULTS

TABLE II: Comparison of CCDF in RNS and DHT

PAPR in db	CCDF FOR RNS	CCDF FOR DHT
0	1	1
1	0.9688	0.9668
2	0.999	0.661
3	0.7932	0.088
4	0.35	0.008

A. Simulation results of PAPR reduction performance of the PTS scheme and the conventional MIMO-OFDM with N=2048, 4QAM/64QAM V=3, W= {-1, 1}, M=3/M=8.

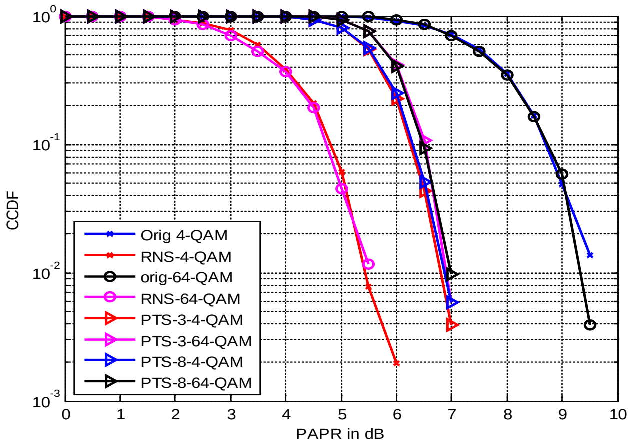

Figure 3

B. Simulation results of PAPR reduction performance of the proposed scheme, PTS scheme, RNS scheme and the conventional MIMO OFDM.

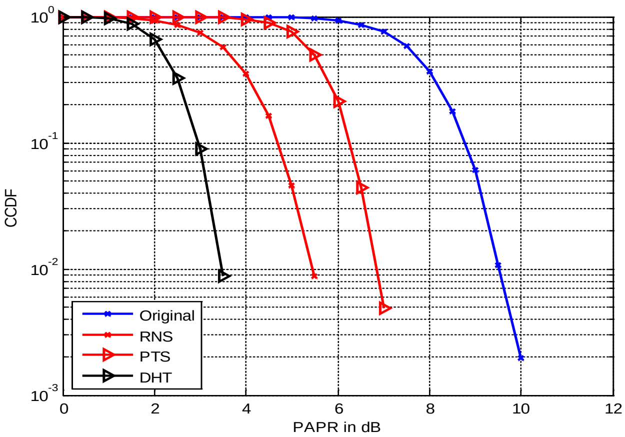

Figure 4

VII. CONCLUSION

In this paper DHT based peak to average ratio reduction scheme is proposed which is better than previously proposed partial transmit sequence (PTS) based and residue number system (RNS) based peak to average ratio reduction scheme for multiple input multiple output orthogonal frequency division multiplexing (MIMO-OFDM) system. According to theoretical analysis and simulation results, DHT based PAPR reduction scheme in MIMO-OFDM is effectively reduced the PAPR without side information.

VIII. FUTURE SCOPE

With my proposed scheme PAPR is reduced about 2 dB with respect to PTS scheme and about 1dB with respect to RNS scheme, which is shown in figure 4

- We will improving this technique as a efficient technique having low implementation complexity which has the potential of compensating both PAPR and ICI problemssignificantly without affecting spectral efficiency of the system.

REFERENCE

[1] N. Bharathi Raja1* and N. Gangatharan2 " A New Low Complexity DHT based Weighted OFDM Transmission forPeak Power Reduction" Indian Journal of Science and Technology, Vol 9(17), DOI: 10.17485/ijst/2016/v9i17/86328, May 2016

[2]]Ji Zhou Yaojun Qiao, Member, IEEE, "Low-PAPR Asymmetrically Clipped Optical OFDM for Intensity-Modulation/Direct-Detection Systems Volume 7, Number 3, June 2015

[3] Chirag V Trivedi1, Anil K Sisodia2, Kiran R Parmar3 "PTS Technique for MIMO-OFDM Paper Reduction" 2014 IJEDR | Volume 2, Issue 2 | ISSN: 2321-9939]

[4] Yu Zhang1, Wei Tang2 "OFDM PAPR Reduction with Digital Amplitude Predistortion" 978-1-4673-5225-3/14/$31.00 ©2014 IEEE

[5] Yi Yao, Jianhao Hu" MIMO-OFDM PAPR Reduction by Residue Number System"IEEE 2013

[6] Beena R. Ballal 1, Ankit Chadha2, Neha Satam3 "Orthogonal Frequency Division Multiplexing and its Applications" international journal for science and research,india online ISSN 2319-7064

[7] ALOK JOSHI1, DAVINDER S. SAINI" Performance Analysis and PAPR Reduction of Coded OFDM (with RSCC and Turbo coding) System using Modified SLM, PTS and DHT Precoding in Fading Environments" Issue 1, Volume 12, January 2013.

[8]] Alaa jalal mohammed(1) ,NeeleshAgrawal "DHT-BASED PRE-CODING FOR PAPR REDUCTION IN MULTICARRIER M-QAM

[9] Haidar N. Al-Anbagi ,Khaled Elleithy" A New Proposed Peak-to-Average Power Reduction Parameter to Evaluate SLM and PTS as OFDMPAPR Reduction Schemes

[10] Manushree Bhardwaj1, Arun Gangwar2, Devendra Soni "A Review on OFDM: Concept, Scope & its Applications" IOSR Journal of Mechanical and Civil Engineering (IOSRJMCE) ISSN : 2278-1684 Volume 1, Issue 1 (May-June 2012), PP 07-11 www.iosrjournals.org

[11] Tao Jiang, Senior Member, IEEE, and Cai Li" Simple Alternative Multisequences for PAPR Reduction Without Side Information in SFBC MIMO-OFDM Systems" IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, VOL. 61, NO. 7, SEPTEMBER 2012

[12] Michela Svaluto Moreolo, Member, IEEE" Performance Analysis of DHT-Based Optical OFDM Using Large-Size Constellations in AWGN" IEEE COMMUNICATIONS LETTERS, VOL. 15, NO. 5, MAY 2011

[13] Sonal Sharma1, Sumit Sharma2, " An Analytical Approach for Efficient OFDM Modulator and Demodulator Communication Systems Based on Discrete Hartley Transform" International Journal of Advanced Computer Research (ISSN (print): 2249-7277 ISSN (online): 2277-7970) Volume-1 Number-1 Issue-1 September 2011

[14] 1Nikhil Arora, 2Prem Singh" Partial Transmit Sequence (PTS)-PAPR Reduction Technique in OFDM Systems with Reduced Complexity" Conference on Advances in Communication and Control Systems 2013 (CAC2S 2013

[15] L. Wang and J. Liu" Cooperative PTS for PAPR reduction in MIMO-OFDM" ELECTRONICS LETTERS 3rd March 2011 Vol. 47 No. 5

[16] Y. Yao and J. Hu, "RNS based ofdm transmission scheme with low papr," in Computational Problem-Solving (ICCP), 2011 International Conference on, oct. 2011,

[17] S. Ma, J. Hu, Y. Ye, L. Zhang, and X. Ling, "A 2 n scaling scheme for signed rns integers and its vlsi implementation," SCIENCE CHINA Information Sciences, vol. 53, no. 1, pp. 203–212, 2010

[18] Damien Roque, Cyrille Siclet and Jean-Marc Brossier, Pierre Siohan "Weighted Cyclic Prefix OFDM: PAPR Analysis and Performances Comparison with DFT-Precoding" 978-1-4673-5051-8/12/$31.00 ©2012 IEEE

[19] Q.Wen, Y. Xiao, P.Cheng, L. Dan, and S. Li, "A modified partial transmit sequence scheme for papr reduction in ofdm system," in Vehicular Technology Conference, 2008. VTC 2008-Fall. IEEE 68th. IEEE, 2008, pp. 1–5.

[20] T. Jiang and Y.Wu, "An overview: Peak-to-average power ratio reduction techniques for ofdm signals," Broadcasting, IEEE Transactions on, vol. 54, no. 2, pp. 257 –268, june 2008.

[21] R. F. Fischer and M. Hoch, "Peak-to-average power ratio reduction in mimo ofdm," in Communications, 2007. ICC'07. IEEE International Conference on. IEEE, 2007

[22]] R. J. Baxley and G. T. Zhou, "Comparing selected mapping and partial transmit sequence for par reduction," Broadcasting, IEEE Transactions on, vol. 53, no. 4, pp. 797–803, 2007

[23]] A. Omondi and B. Premkumar, Residue number systems: theory and implementation. Imperial College Press, 2007

[24] Hongwei Yang," A Road to Future Broadband Wireless Access: MIMO-OFDM-Based Air Interface" IEEE Communications Magazine • January 2005