SLM AND PTS TECHNIQUES TO REDUCE PAPER

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Abstract— Multiple input multiple output orthogonal frequency division multiplexing (MIMO-OFDM) is an attractive transmission technique for high-bit-rate communication systems. To achieve high speed, data rate and simultaneous increase in range and reliability without consuming extra radio frequency requires MIMO-OFDM for wireless broadband communication. Multiple input multiple output orthogonal frequency division multiplexing (MIMO-OFDM) technology effectively combats the multipath fading channel and improves the bandwidth efficiency. But the high Peak-to-Average Power Ratio (PAPR) is one of the main obstacles to limit wide applications of OFDM-MIMO due to large number of sub-carriers. In this paper, based on the research of selective mapping (SLM) and partial transmit sequences (PTS) scheme are studied.

Key words- OFDM, MIMO, PAPR, SLM, PTS, etc.

I. INTRODUCTION

In recent years, the multiple input multiple output orthogonal frequency division multiplexing (MIMO-OFDM) is a promising technique for high-bit-rate transmission. In OFDM data is transmitted simultaneously through multiple frequency bands, the effects of multipath delay spread can be minimized. OFDM has been proposed for many radio systems such as the next generation mobile communication, wireless LAN, digital audio/video broadcasting, and high-speed cellular data. However, one of the main disadvantages of OFDM is its high Peak-to-Average Power Ratio (PAPR). When N signals are added with the same phase, they produce a peak power that is N times the average power [2].

To combat increase in PAPR, one intuitive solution is to minimize correlation of input bits. The outline of the paper is as follows. Sect. 2 describes OFDM and MIMO System. Definition of PAPR is described in Sect. 3, two distinctive types of PAPR reduction techniques are discussed in Sect. 4 and proposed system described in sect.5 and simulation results in sect. 6. Conclusions of paper are presented in Sect. 7.

II. OFDM-MIMO SYSTEM

OFDM can be generated using multiple modulated carriers transmitted in parallel. However, this method involves implementation problems and makes transmitters more complex and expensive. This problem can be avoided by the use of the discrete Fourier transform (DFT) technique and can be implemented efficiently using the inverse fast Fourier transform (IFFT) algorithm [4].

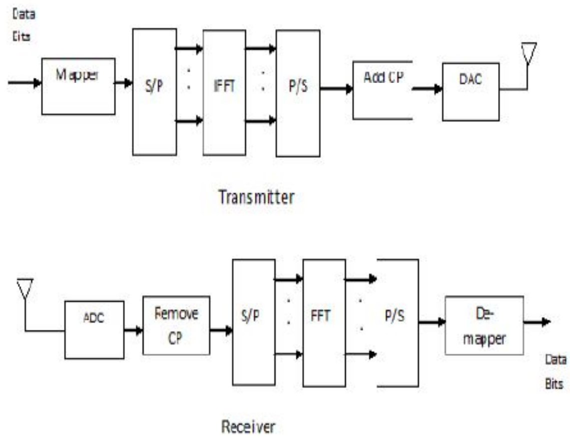

Fig.1. Simple OFDM Model [4]

A typical OFDM transmission system is shown in Fig. 1. At the transmitting end, first of all, input binary serial data stream is first processed by constellation mapping and serial to parallel (S/P) conversion. A single signal is divided into *N* parallel routes after *N*-point inverse fast Fourier transform (IFFT). Next, convert modulated parallel data to serial sequence and then copy the last L samples of one symbol to the front as cyclic prefix (CP). At last, arrive at transmitter after process of digital to analog (D/A) conversion and radio frequency (RF) modulation. To recover the information in OFDM system, reception process is converse and self-explanatory [6].

At the transmitting end, a number of transmission antennas are used. An input data bit stream is supplied into space-time coding, then modulated by OFDM and finally fed to antennas for sending out. At the receiving end, in-coming signals are fed into a signal detector and processed before recovery of the original signal is made [1].

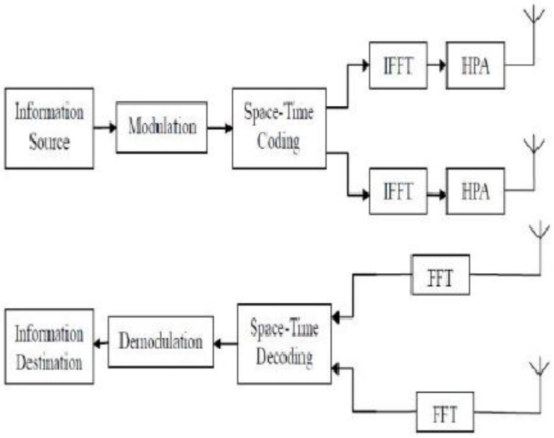

Fig.2. Basic Structure of MIMO-OFDM System

III. PEAK TO AVERAGE POWER RATIO (PAPR) IN OFDM-MIMO

For an OFDM signal with N subcarriers, the PAPR [2] can be defined as:

$$PAPR = \frac{P_{peak}}{P_{avg}} = 10log_{10}\frac{max[|x_n|^2]}{E[|x_n|^2]} \ldots..(1)$$

In particular, a baseband OFDM signal with N sub carrier has

$$PAPR_{\max}(dB) = 10log_{10}N\ (dB) \ldots..\ (2)$$

The crest factor (CF) is widely used as well, which is defined as the square root of the PAPR.

$$CF = \sqrt{PAPR} \ldots\ldots\ (3)$$

From the central limit theorem, it follows that for large values of N (N>64), the real and imaginary values of $x(t)$ become Gaussian distributed. Therefore the amplitude of the OFDM signal has a Rayleigh distribution, with a cumulative distribution given by

$$F(z) = 1 - \exp(-z) \ldots.(4)$$

The probability that the PAPR is below some threshold level can be written as

$$P(PAPR < z) = F(z)^N = (1 - \exp(-z))^N \ldots.(5)$$

In fact, the complementary cumulative distribution function (CCDF) of PAPR is usually used, and can be expressed as

$$P(PAPR > z) = 1 - F(z)^N = 1 - (1 - \exp(-z))^N \ldots\ldots(6)$$

IV. SCRAMBLING TECHNIQUES

The emergence of high peak power signal in OFDM system is due to the superposition (IFFT operation) of multiple sub-carrier signals. If multiple sequences which carry the same information are used to represent one transmission process, then the best one can be chosen among those candidates for a given PAPR threshold condition. In this way the occurrence probability of peak power signal can significantly be reduced.

Phase rotation method contains a lot of different schemes. However, until now, there exist two most effective and meritorious proposals which are called SLM and PTS [6].

SELECTED MAPPING METHOD (SLM)

The CCDF of the original signal sequences PAPR above a threshold $PAPR_0$ is written as $\{PAPR>PAPR_0\}$. Thus for K statistical independent signal waveforms, CCDF can be rewritten as $[\{PAPR>PAPR_0\}]^K$, so that the probability of PAPR that exceeds the same threshold will drop to a small value. [1]

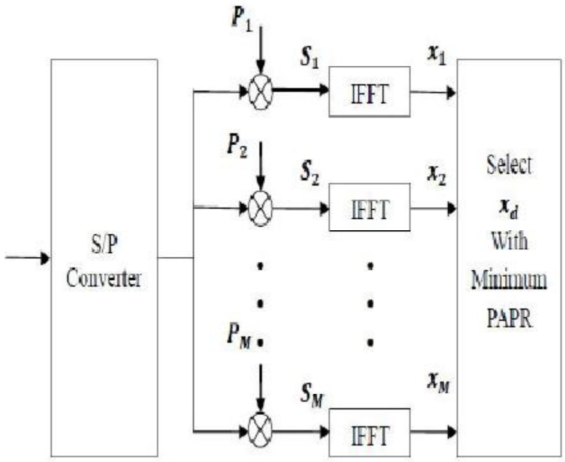

Fig.3. Basic Principles of Selected Mapping [6]

The probability of PAPR larger than a threshold z can be written as $(PAPR>z) = 1-(1-\exp(-z))$. Assuming that M OFDM symbols carry the same information and that they are statistically independent of each other. In this case, the probability of PAPR greater than z is equals to the product of each independent candidate's probability. This process can be written as

$$\{PAPR_{low}>z\}=(\{PAPR>Z\})^M=(1-\exp(-z))^N)^M \ldots..(7)$$

PARTIAL TRANSMIT SEQUENCE (PTS)

Partial Transmit Sequence (PTS) algorithm is a technique for improving the statistics of a multi-carrier signal. The basic idea of partial transmit sequences algorithm is to divide the original OFDM sequence into several sub-sequences, and for each sub-sequence, multiplied by different weights until an optimum value is chosen.

From the fig.4, we see that the data information in frequency domain X is separated into V non-overlapping sub-blocks and each sub-block vectors has the same size N. Hence, we know that for every sub-block, it contains N/V nonzero elements and set the rest part to zero.

Assume that these sub-blocks have the same size and no gap between each other, the sub-block vector is given by

$$\hat{X} = \sum_{v=1}^{V} b_v X_v \ldots.(8)$$

Where $b_v=(\varphi_v\in[0,2\pi])v=1,2,\ldots,V$ is a weighting factor been used for phase rotation. The signal in time domain is obtained by applying IFFT operation on , that is

$$\hat{x} = IFFT(\hat{X}) = \sum_{v=1}^{V} b_v IFFT(X_v) = \sum_{v=1}^{V} b_v \cdot (x_v) \text{….(9)}$$

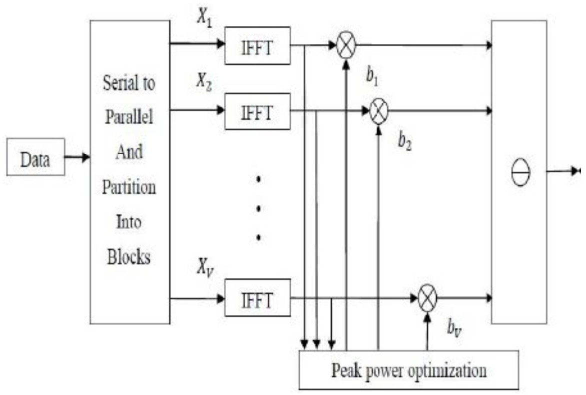

Fig.4. Block Diagram of PTS Algorithm [6]

Select one suitable factor combination **b**=[$b1,b2,\ldots,bv$] which makes the result achieve optimum. The combination can be given by

$$b = [b_1, b_2, \ldots, b_v] = argmin_{(b_1, b_2, \ldots, b_v)} (max_{1 \le n \le N} |\sum_{v=1}^{V} b_v \cdot (x_v)|^2) \text{..(10)}$$

Where, argmin (·) is the judgment condition that output the minimum value of function. In this way we can find the best **b** so as to optimize the PAPR performance. The additional cost we have to pay is the extra *V*-1 times IFFTs operation [6].

CONVOLUTIONAL CODES

Convolutional codes [20] differ from block codes in that the encoder contains memory and the *n* encoder outputs at any time unit depend not only on the *k* inputs but also on *m* previous input blocks.

An (*n, k, m*) convolutional code can be implemented with a *k*-input, *n*-output linear sequential circuit with input memory *m*.

A convolutional code is generated by passing the information sequence to be transmitted through a linear finite-state shift register. In general, the shift register consists of *K* (*k*-bit) stages and n linear algebraic function generators.

Typically, *n* and *k* are small integers with $k<n$, but the memory order *m* must be made large to achieve low error probabilities.

A SLM SCHEME WITH RIEMANN MATRIXES

Selecting of proper phase sequences to achieve good PAPR reduction is very important in SLM. Different phase sequence sets as Riemann matrix [12], [15], [13], interferomrtry code sequence [3], Hibert matrix, Hadamard matrix, Circulant matrix [17], are proposed in literatures for PAPR in SLM or PTS schemes. Phase sequence set was chosen randomly from {±1, ±*j*} [2].

The rows of normalized Riemann matrix can be selected as phase sequence set in SLM. The Riemann Matrix is obtained by removing the first row and first column of the matrix B, where

$$B(i,j) = \begin{cases} i-1 & if\ i\ divides\ j \\ -1 & otherwise \end{cases} \text{…..(11)}$$

Riemann Matrix (B) of order 2, can be written as:

$$B = \begin{bmatrix} 1 & -1 \\ -1 & 2 \end{bmatrix} \text{…..(12)}$$

Define $B^{(v)} = [B_0^{(v)}, B_1^{(v)}, \ldots, B_{N-1}^{(v)}]$ with each row of the normalized Riemann matrix B. Each input data block $X = [X_0, X_1, \ldots, X_{N-1}]$ is multiplied with V different phase vectors $B^{(u)}$□, v □1,2,…,V .Then, and all V subcarrier vectors are transformed into time domain to get

$$x^{(v)} = IFFT\{X^{(v)}\} = IFFT\{X_n . B_n^{(v)}\} \text{….(13)}$$

Finally, the one with the minimum PAPR is selected for transmission.

V. PROPOSED SYSTEM

The PAPR reduction technique proposed in this paper is based on the technique proposed in paper [1]. However, whereas in Proposed technique, discussed in [1], the phase sequence set was chosen randomly from [_±1,±j], but in the proposed technique of this paper the diagonal of the normalized Riemann matrix are used as phase sequence set for PAPR reduction. In fact the proposed technique of this paper is the modification of the proposed technique discussed in paper [1]. Here, in proposed technique of this paper, first SLM technique using diagonal of normalized Riemann matrix as a phase sequence set is applied to select the best combination of phase and input data with coding and interleave application which gives the minimum PAPR. Same methodology is applied to PTS technique also to get minimum PAPR.

The algorithm for proposed SLM technique can be described in following steps:

1. The sequence of data bits are first coded using convolution coding and then interleave the coded sequence.
2. The sequences of coded data bit are mapped to constellation points QPSK to produce sequence symbols X_0, X_1 ….
3. These symbol sequences are divided into blocks of length N. N is the number of sub-carriers.
4. Each block is multiplied (point wise multiplication) by M different phase sequence vector
$$B^{(m)} = [B_0^{(m)}, B_1^{(m)}, \ldots, B_{N-1}^{(m)}],$$
where diagonal of the normalized Riemann matrix B is used.
5. A set of U different OFDM data block
$$X^{(m)} = [X_0 B_0^m, X B_1^m, \ldots, X_{N-1} B_{N-1}^m]$$
6. Transform into time domain to get
$$x_m = IFFT[X_n^m]$$
7. Select the one from x^m,m=0,1..,M-1, which has the minimum PAPR.

The algorithm for proposed PTS technique can be described in following steps:

1. The sequence of data bits are first coded using convolution coding and then interleave the coded sequence.
2. The sequences of coded data bit are mapped to constellation points QPSK to produce sequence symbols X_0, X_1 ….
3. These symbol sequences are divided into V blocks of length N. N is the number of sub-carriers.
4. Each block is transform into time domain to get
$$x_n = IFFT[X_n].$$
5. Each time domain block multiplied by V different phase sequence vector
$$B^{(v)} = [B_0^{(v)}, B_1^{(v)}, \ldots\ldots, B_{N-1}^{(v)}],$$
where diagonal of the normalized Riemann matrix B is used and add all set of V different OFDM data block,
$$x^{(v)} = [x_0 B_0^v, x_1 B_1^v, \ldots.., x_{N-1} B_{N-1}^v,].$$
6. Determine the PAPR of OFDM sequence. Let it be PAPR1.
7. Now with different phase sequences determine PAPR. Let it be PAPR2.
8. If PAPR2<PAPR1, then retain the phase sequence, else change the phase sequence.
9. Repeat the Steps until the phase sequence with minimum PAPR is obtained.

VI. SIMULATION RESULTS

In this section the PAPR reduction performance of the proposed technique, discussed in previous section, is analyzed. This Proposed technique is also compared between SLM, PTS with phase sequence [±1, ±j] and Riemann sequence. Simulation has been done in MATLAB and following parameters have been considered for simulation purpose:

Table1. Simulation Parameters

Simulation parameter	Type/Value
Number of subcarriers(N)	1024
Number of sub blocks SLM PTS	 M=4 V=4
Oversampling factor(K)	8
Modulation Scheme	OPSK
Phase factor	[+1, +j] and Riemann Sequence
Coding	Convolution coding

Figure 5 to Figure 8 show the graphs for the complement cumulative distribution function (CCDF) of PAPR in original and proposed PTS, SLM techniques for V=4 and M=4 sub-blocks respectively.

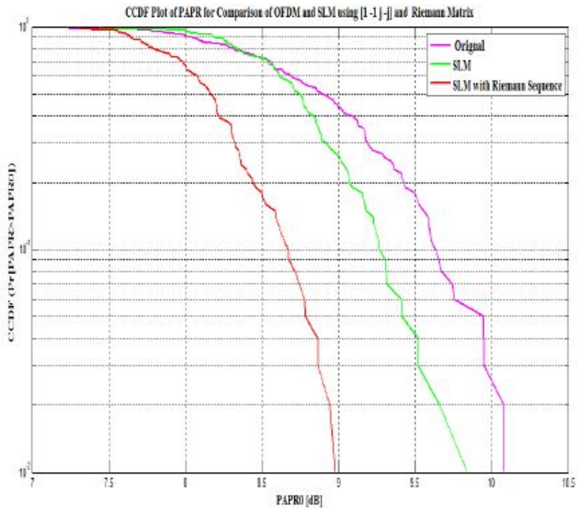

Fig.5. CCDF's of PAPR in original and modified SLM

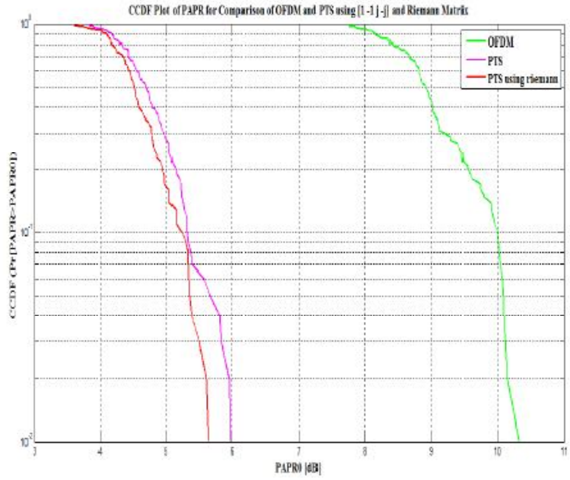

Fig.6. CCDF's of PAPR in original and modified PTS

From fig 5, when PAPR distribution is 10e-2 then PAPR for OFDM is 10.2dB, for SLM is 9.8dB and for SLM using Riemann Sequence is 9dB. Similarly from fig 6, when PAPR distribution is 10e-2 then PAPR for OFDM is 10.2dB, for PTS is 6dB and for PTS using Riemann Sequence is 5.6dB. Using Riemann sequence in SLM and PTS technique the PAPR ratio is reduced than using [±1, ±j] sequences.

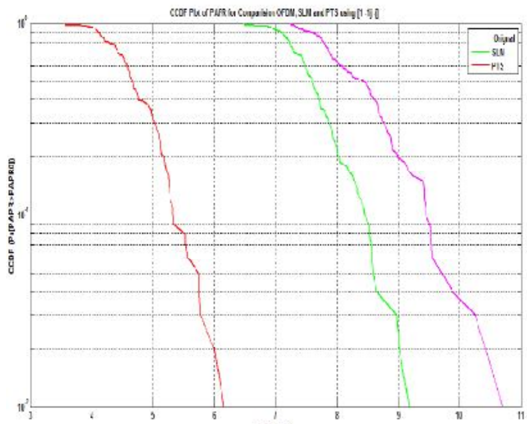

Fig.7. CCDF's of PAPR in original SLM and PTS

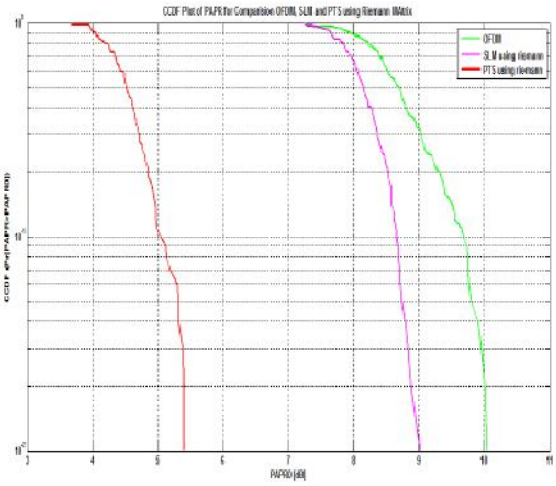

Fig.8. CCDF's of PAPR in modified SLM and PTS

From fig 7, when PAPR distribution is 10e-2 then PAPR for OFDM is 10.6dB, for SLM is 9.2dB and for PTS is 6.1dB. Similarly from fig 8, when PAPR distribution is 10e-2 then PAPR for OFDM is 10dB, for SLM using Riemann Sequence is 9dB and for PTS using Riemann Sequence is 5.4dB. PTS technique is better than SLM technique using both [±1, ±j] and Riemann Matrix Sequences. But better results are obtained using Riemann sequence.

From the simulation results, it is clear that proposed technique can achieve more PAPR reduction when compared to PTS, SLM techniques. Moreover, the performance of proposed technique becomes better & better as the number of sub-blocks increase.

CONCLUSION

Power efficiency is an important criterion in mobile communication. So, it became clear that PAPR has to reduce in OFDM. The Selective Mapping (SLM) and Partial Transmit Signal (PTS) are two best techniques to reduce PAPR. The SLM and PTS using Riemann sequence as phase rotation factor achieve more reduction in PAPR. No need to transmit side information at receiver. The simulation results show that original techniques can lower the PAPR but proposed techniques offer better PAPR reduction. The SLM and PTS techniques are used as per requirement of application.

REFERENCES

[1] K Srinivasarao1, Dr B Prabhakararao, and Dr M V S Sairam, "Peak-To-Average Power Reduction In MIMO-OFDM Systems Using Sub-Optimal Algorithm", *International Journal of Distributed and Parallel Systems (IJDPS)* Vol.3, No.3, May 2012, pp:261-273.

[2] Lin Chen, Xuelong Hu, "A Modified SLM Scheme for PAPR Reduction", *2010 3rd International Congress on Image and Signal Processing (CISP2010 ©2010 IEEE)*, pp:4299-4302.

[3] Jizeng Wang, Jingyu Luo, Yanlong Zhang , "A New Phase Sequence for SLM in MC-CDMA System", *1-4244-1312-5/07/$25.00 © 2007 IEEE*, pp:938-942.

[4] Yasir Rahmatallah, Seshadri Mohan, "Peak-To-Average Power Ratio Reduction in OFDM Systems: A Survey and Taxonomy", *IEEE Communications Surveys & Tutorials, Vol. 15, No. 4, Fourth Quarter 2013*, pp: 1567-1592.

[5] Wang Yi, Gu linfeng, "An Investigation of Peak-to-Average Power Reduction in MIMO-OFDM Systems", *Blekinge Institute of Technology School of Engineering* Department of Electrical Engineering.

[6] Yun Li, MingyuGao, Zhiqiang Yi, "A cooperative and alternate PTS scheme for PAPR reduction in STBC MIMO-OFDM system", *Communication Technology (ICCT), 2012 IEEE 14th International Conference*, pp:268 – 272.

[7] Aladdin Amro, "A Flexible OFDM System Simulation Model with BER Performance Test", *Contemporary Engineering Sciences*, Vol. 5, 2012, no. 8, 365 – 374.

[8] B K Mishra, Rajesh S. Bansode, KavitaBani, "OFDM PAPR Reduction using Selective Level Mapping and π/4-Shifted-DQPSK Modulation"*2nd International Conference and workshop on Emerging Trends in Technology (ICWET) 2011 Proceedings published by (IJCA).*

[9] Devashree H. Patil, Rajesh S. Bansode, Geeta H. Karande, "Performance Enhancement of MIMO-OFDM System using PTS to achieve optimum BER & PAPR", *IPASJ International Journal of Electronics & Communication (IIJEC,)*Volume 2, Issue 8, August 2014 ISSN 2321-5984.

[10] Wanis Mohamed, "Reducing Peak to Average Power Ratio of OFDM by Using Selected Mapping", California State University, Northridge, May 2012.

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