PTS Technique for MIMO-OFDM Paper Reduction

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***Abstract*— Non linearity of High Power Amplifier will increase the bit error rate and hence it is necessary to perform back off from nonlinear region to linear region OFDM technology is widely used in current 4G standard. While Performing IFFT there is a possibility that some signals may be added with same phase and hence increasing peak power of signal which cease to increase peak to average power ratio (PAPR).MIMO-OFDM technology uses multiple transmitter and multiple receiver in combination to OFDM technology which leads to same problem of PAPR on different paths from multiple transmitter to multiple receiver. In this paper we discussed PTS technique for PAPR reduction OFDM technology, simulation of theoretical Complementary Cumulative Distributive Function (CCDF) of MIMO-OFDM technology is given in paper.**

Keywords— Multiple Input Multiple Out (MIMO), Peak to Average Power Ratio (PAPR), Orthogonal Space Time Block (OSTBC), partial transmit sequence (PTS), selective mapping technique (SLM). Input back off (IBO), Output back off (OBO) Discrete Cosine Transform (DCT), High Power Amplifier (HPA)

I. INTRODUCTION

MIMO-OFDM system have attracted very much for future wireless broadband communication. OFDM mitigates the effect of frequency selective fading by converting several wideband channels in to narrow band flat fading channels. MIMO system increases the system capacity significantly over single antenna system. [1]

Practical design of OFDM system shows that PAPR problem is very much important to solve because large linear range will cease to increase the cost to connected devices to the high power amplifier. Theoretical results of CCDF of MIMO system is compared with SISO system which shows that in MIMO system we have flexibility to choose among different number of paths which can have lowest PAPR. In this paper effect of saturation level Vs BER is plotted for 8-PSK 16-QAM and 64-QAM signal.

Various variants of PTS technique like using Riemann sequence as a set of phase factors, individual optimization of real and imaginary parts, Use the property of Discrete Cosine Transform(DCT) which is having property of low autocorrelation function were analysed . simulation of low complexity binary PTS technique for variation of different number of FFT point is also shown here which uses binary phase factors like {1,-1}

II. THEORITICAL CCDF OF MIMO-OFDM SYSTEM

A single signal is divided into N parallel streams after passing through N-point inverse fast Fourier transform (IFFT). Each orthogonal sub-carrier is modulated by one of the N data routes independently. After serial to parallel conversion this N symbols is given by [1]

$$X = [X^0, X^1, X^2 \dots \dots \dots \dots . X^{V-1}]^T \qquad (1)$$

X is then processed through the IFFT block to give

$$X = WX \qquad (2)$$

Where, W is the $N \times N$ IFFT matrix. Thus, the complex baseband OFDM signal with N subcarriers can be written as [1]

$$x_n = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} dX_k e^{\frac{j2\pi kn}{N}} \qquad n = 0,1, \dots . N-1 \qquad (3)$$

PAPR is the ratio between the maximum power and the average power of the complex pass band Signal, that is,[1]

$$PAPR\{S(t)\} = \frac{\max |Re(s(t)e^{j2\pi f_c t}|^2}{E\{|Re(s(t)e^{j2\pi f_c t}|^2\}} = \frac{\max |s(t)|^2}{E\{|s(t)|^2\}} \qquad (4)$$

Amplitude of OFDM signal follows Raleigh distribution. Let {zn} be independent identically distributed random variable then cumulative distributive function Zmax is given as follows

$$fZ_{\max}(z) = P(z_{\max} < z)$$

$$= (Z_0 < z)P(Z_1 < z) \dots \dots \dots P(Z_{N-1} < z) \qquad (5)$$

$$= (1 - e^{-z^2})^N$$

Here crest factor (CF) is given by maximum of Zn .we now find crest factor which exceeds z, we consider following complementary CDF.

$$\begin{aligned} fZ_{max}(z) &= P(z_{max} > z) \\ &= 1 - P(z_{max} \le z) \\ &= 1 - Fz_{max}(z) \\ &= 1 - (1 - e^{-z^2})^N \end{aligned} \qquad (6)$$

This equation doesn't hold true for oversampled signal because digital sampled signal may not contain all the peaks of analog signals more over value of oversampling factor(α)=2.8 is used to approximately get the same PAPR in digital and analog signals. Formula for oversampling signal is as given below.

$$F_Z(z) = 1 - (1 - e^{-z^2})^{N*\alpha} \qquad (7)$$

For Mt Transmit antenna the CCDF will be given by the following formula

$$F_Z(z) = 1 - (1 - e^{-z^2})^{N*Mt*\alpha} \qquad (8)$$

Following simulations shows the comparison of MIMO and SISO theoretical CCDF Vs PAPR with and without oversampling.

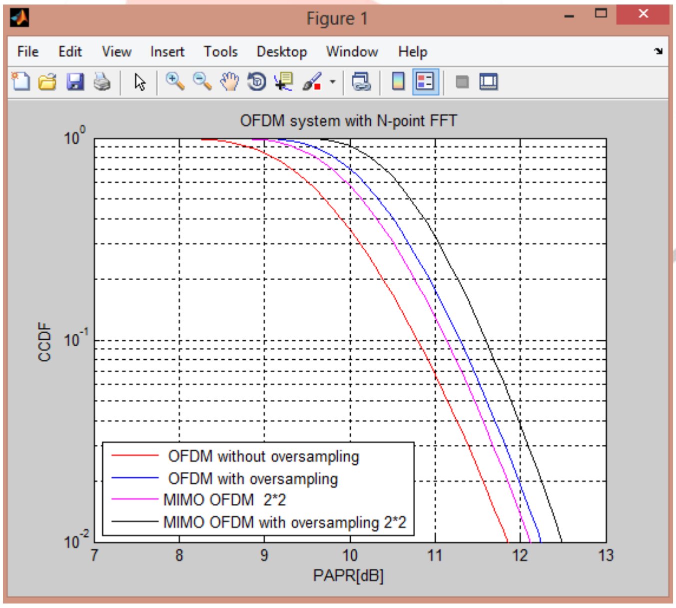

Figure 1: theoretical simulation of CCDF vs PAPR for MIMO and OFDM system

III. NON LINEARITY IN HIGH POWER AMPLIFIER (HPA)

Characteristics of high power amplifier (HPA) can be explained in terms of the input power Pin and the output power Pout. The input power must be backed off to operate in linear region therefore; back off from nonlinear region is described by input back off (IBO) and output back off (OBO)[23]

$$\begin{aligned} IBO &= 10\log_{10}\frac{P_{in}^{max}}{P_{in}} \\ OBO &= 10\log_{10}\frac{P_{out}^{max}}{P_{out}} \end{aligned} \qquad (9)$$

Nonlinear characteristics of HPA shows that when large input out of linear range arrives received signal will be attenuated, rotated as well as offset in phase is experience.[23]

To see the effect of high power amplifier we simulated RF satellite link for QPSK modulation scheme and analyzed the non-linearity effect of RF satellite link with sever non linearity near saturation region in HPA as well as moderate non linearity and negligible non linearity in HPA

The figure shows transmit signal after passing it through raised cosine filter and receiving on receiver side after High Power Amplifier. Simulation results shows that when we perform more back off that means we are operating in linear region and bit error rate is reduced whereas going towards saturation region bit error rate is increased.

30 dB back off negligible non linearity

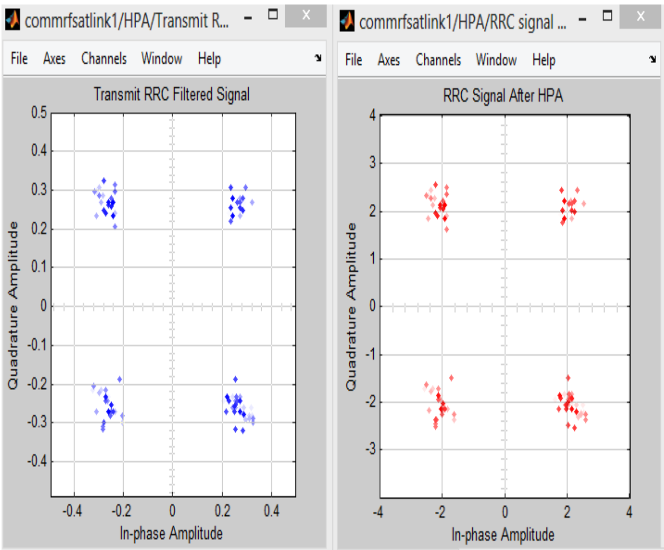

Figure 2: raised cosine signal and Signal after HPA with negligible non linearity QPSK[23]

7dB back off moderate nonlinearity

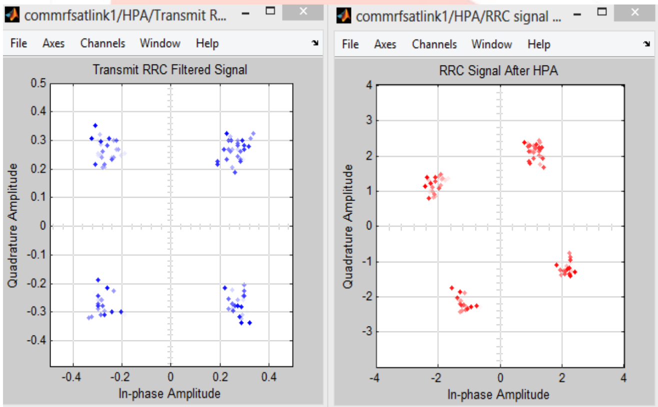

Figure 3: raised cosine signal and Signal after HPA with moderate non linearity QPSK[23]

1dB back off server nonlinearity

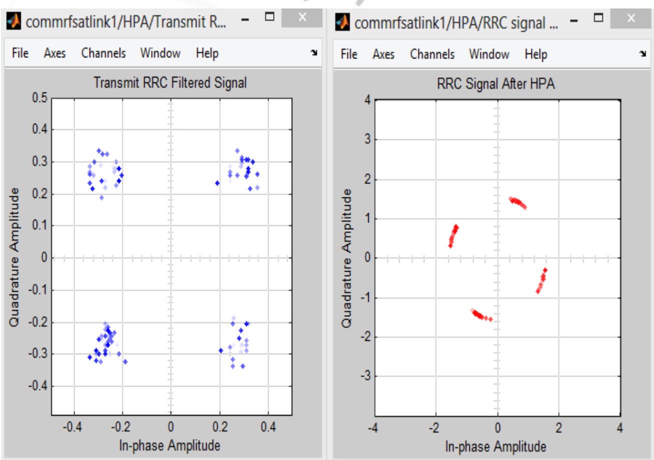

Figure 4: raised cosine signal and Signal after HPA with sever non linearity QPSK [23]

To see the effect of how PAPR affects the BER simulation was done with different modulations schemes like 8-psk, 16-QAM and 64-QAM and plot of BER Vs Saturation level in High Power Amplifier. Analysis of simulation results shows that as the value of Saturation level in HPA increases the value of BER is gradually decreasing this is due to increase in linear range of High Power amplifier. So we can conclude that as linear range is increasing BER value will decrease. It can be observed that as the modulation order is increased BER value is increasing that is because higher order modulation schemes have symbols very close to each other and leads to higher BER when passed through High Power Amplifier (HPA)

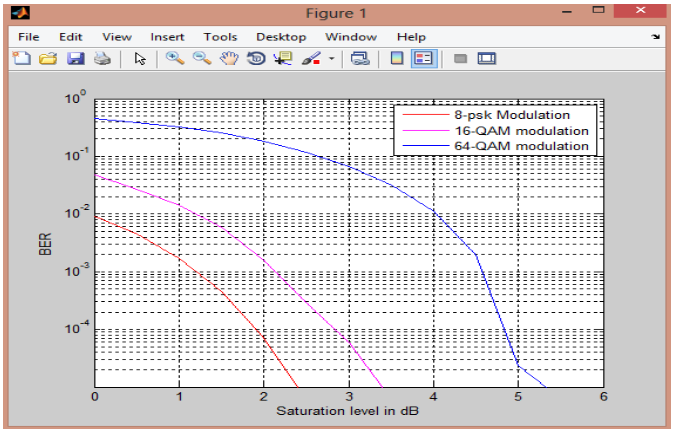

Figure 5: effects for different modulation BER Vs Saturation level in dB

IV. PTS TECHNIQUE FOR PAPR REDUCTION

Several techniques have been proposed to Reduce PAPR. These techniques can mainly be categorized in to signal scrambling Techniques and signal distortion techniques.

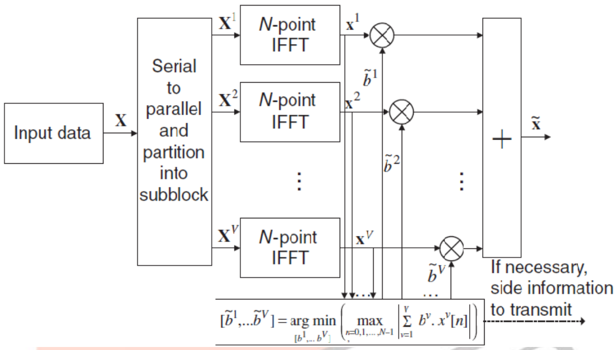

Figure 6: conventional PTS technique for PAPR reduction [1]

Partial transmit sequence divides input data block of N symbols into V disjoint sub blocks as shown below

$X = [X^0, X^1, X^2 \ldots\ldots\ldots\ldots\ldots X^{V-1}]^T$ (10)

Where Xi are consecutively located and equal size blocks. Unlike SLM technique in which information is scrambled (rotating its phase independently) with phase sequence in PTS technique each partitioned sub block is multiplied with complex phase factor $b^v=e^{j\varnothing v}$

Where v= 1, 2, 3….V.

Taking its IFFT will give equation like below

$$x = \mathrm{IFFT}\left\{\sum_{v=1}^{V} b^v X^v\right\}$$

$$= \sum_{v=1}^{V} b^v . \mathrm{IFFT}\{X^v\} \qquad (11)$$

$$= \sum_{v=1}^{V} b^v x^v$$

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

For V sub block and W phase factors W^{V-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 lock [15]

To reduce the complexity we use Rows of Riemann matrix as a set of phase factors which doesn't require to send side information at receiver this reduces complexity in addition we know low autocorrelation property between consecutive symbols of DCT(discrete cosine transform) which reduces PAPR. Combining both methods will simultaneously reduce PAPR as well as reduce complexity with no requirement of side information to be transmitted. Following results shows comparison of PAPR using this combination technique.[21]

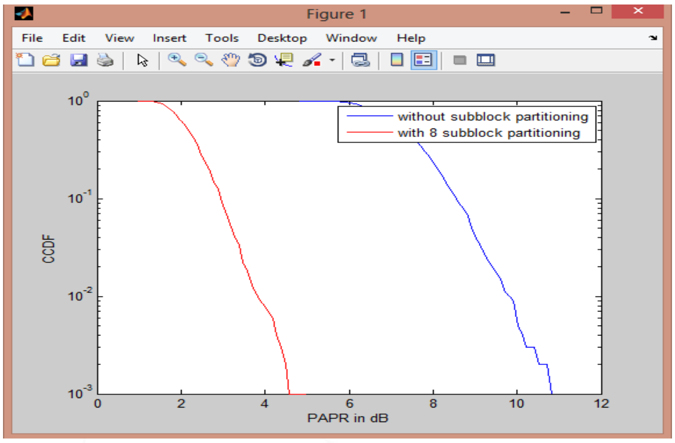

Figure 7: 8 sub block partitioning with conventional PTS technique

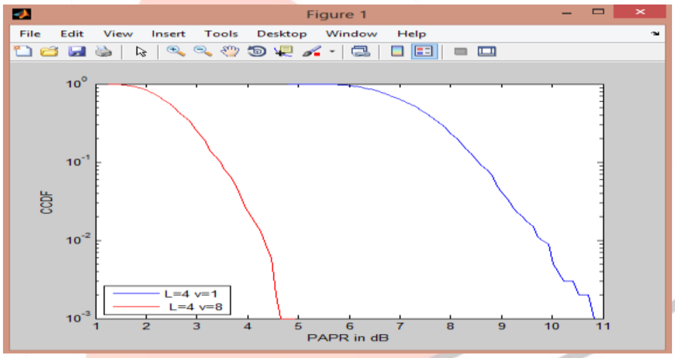

Figure 8 :8 sub block partitioning with Riemann sequence NN=1000; L=4; N=64

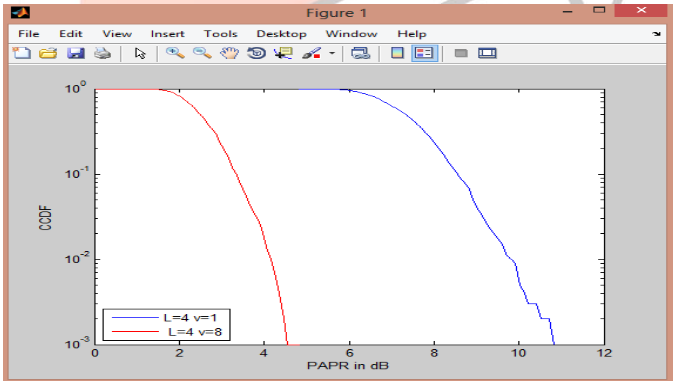

Figure 9 : 8sub block partitioning with combined Riemann matrix and DCT matrix

V. SUBOPTIMAL ALGORITHM OF PTS TECHNIQUE FOR PAPR REDUCTION

In suboptimal combination algorithm use of binary phase factors like {1,-1} is used steps for suboptimal algorithm which reduces computational complexity is given below as if and else loop or case statement can be used to do product of phase factors with data set hardware synthesisation can be possible using this method.

Following algorithm is used to find PAPR using binary phase factors {1,-1}[1][19]

1) Dividing input data blocks in to V different sub blocks
2) Let W=1 and for all sub blocks and find PAPR and assign this PAPR as MIN_PAPR
3) Now let V=2
4) Find PAPR using W=-1

5) If PAPR>PAPR_min, switch W back to 1. Otherwise, update PAPR_min=PAPR.
6) If v < V then increment the v by 1 and go back to step 4 otherwise terminate the process with given phase factors.

The number of computation in suboptimal algorithm is V which is very much below W^{V}
Simulation for this technique with variation of number of FFT points is shown below which shows that as the value of FFT points or number of subcarriers are increasing the value of PAPR is increasing.

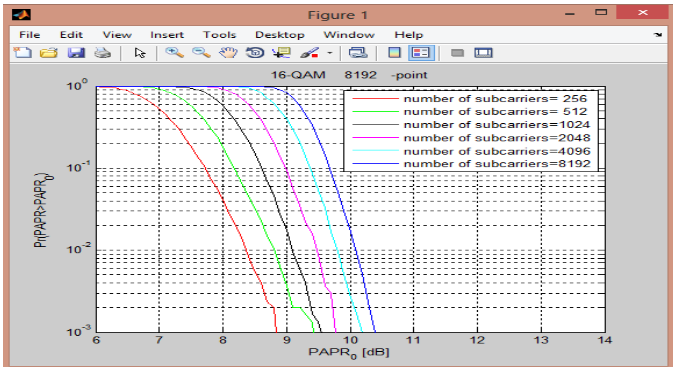

Figure 10 : variation of number of subcarriers 16-QAM[1]

VI. CONCLUSION

In this paper we analyzed theoretical PAPR for MIMO-OFDM system with and without oversampling. Theoretical results show that MIMO system in conjunction with OFDM system possesses Problem of PAPR on multiple paths and hence it is critical to solve this issue.

To reduce Complexity we use Rows of Riemann Matrix as a phase factors and To reduce PAPR we use autocorrelation property of DCT combination of both technique can give reduced PAPR with reduced complexity as shown in simulation.

Moreover use of binary phase factors like {1,-1} as a phase factors we analyzed effect of varying number of subcarriers results shows support to theoretical proofs that by increasing FFT points PAPR is increased.

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