Communications on Applied Electronics (CAE) – ISSN : 2394-4714
Foundation of Computer Science FCS, New York, USA
International Conference on Communication Technology (ICCT 2015) – www.caeaccess.org

Improved PAPR Reduction for STBC-MIMO-OFDM by using New Phase Factor with Four Transmitting Antennas

Shilpa A. Talele
Student ME(EXTC)
YTIET, Bhivpuri Road ,
Karjat,Mumbai,

Aarti G. Ambekar
Assistant Professor
D.J.Sanghavi College of
Engg., Mumbai

Deepshikha Hinger
Assistant Professor
D.J.Sanghavi College of
Engg.,Mumbai,

ABSTRACT
In the modern world, wireless communications have been developed very rapidly and demand for multimedia services is growing day by day. Higher bandwidth over wireless network is requirement of communication systems. These systems are implemented using multi carrier frequencies for providing higher data transmission rate and mobility of user and these systems are implemented with use of MIMO OFDM (Multiple Input Multiple Output Orthogonal Frequency Division Multiplexing) technique. The MIMO OFDM have limitations of high PAPR and carrier frequency offset sensitivity. Integration of STBC with MIMO OFDM over frequency selective channel is implemented to improve further PAPR performance. In this frequency selective channel is converted to several flat fading channels thereby eliminating ISI. This technique STBC MIMO-OFDM has high Peak-to-Average Power Ratio (PAPR) also. To achieve better performance this PAPR also has to be reduced. In this paper, variation of different parameters like number of subcarriers, OFDM symbols and its effect on PAPR has been presented. Simulation Results show that reduction of PAPR is possible with increase in phase factor with four transmitting antennas.

Keywords
OFDM, MIMO, STBC, modified PTS, ISI, QPSK, phase factor.

1. INTRODUCTION
Orthogonal Frequency Division Multiplexing(OFDM) is widely used modulation technique for achieving high data rate in wireless communication system and it is an effective technique to the frequency selective fading. Wireless digital communications are rapidly expanding, resulting in a large demand for wireless systems which are reliable and have a high spectral efficiency. With the constant demand of high spectral efficiency and high transmission speed for audio, video and internet applications, Multiple Input Multiple Output-Orthogonal Frequency Division Multiplexing i.e. MIMO-OFDM has become the most promising technology combination for present and future wireless communications. MIMO offers spatial diversity and therefore increase the capacity while OFDM allow systems to work in time varying or frequency selective environment [4].

To improve wireless system capacity, reliability and range MIMO take advantage of the spatial diversity obtained by placing separate antennas in a dense multipath scattering environment. MIMO is implemented in a number of different ways to obtain either a diversity gain or to enhance the channel capacity[3]-[1]-[5]. MIMO-OFDM is the promising candidate for 4G broadband wireless communication. However, the main limitation of using MIMO-OFDM suffers with the problem of high PAPR and carrier frequency offset sensitivity. Space Time Block Coding (STBC) is an effective and practical way to implement with MIMO to improve the reliability of the transmission, as redundant copies of the original data are sent over independent fading channels. To achieve full transmit diversity for given number of antennas the codes are orthogonal. Usually, the radio system uses HPA in the transmitter side to obtain the maximum output power efficiency. The difference of the signal amplitude occur duo to the non-linear characteristics of the HPA. This difference in OFDM amplitudes very high with high PAPR. Hence, it is important to reduce the PAPR; otherwise, high power amplifiers (HPA) in the transmitter need to have a linear region that is much larger than the average power, which makes them expensive and inefficient. This is because if an HPA with a linear region slightly greater than the average power is used, the saturation caused by the large peaks will result in inter modulation distortion. The intermodulation of signal results in increase of the bit error rate (BER) and spectral widening, which generates adjacent channel interference (ACI). The design of a system with lower PAPR depends on requirement of system and different parameters are taken in to account for the same. The various parameter are transmit power, data rate, BER, computational complexity (receiver end). A number of techniques were proposed to control the PAPR as partial transmit sequences (PTS)[9]-[10], selective mapping (SLM)[6]-[7], clipping, clipping and filtering, coding, tone reservation (TR) and tone injection (TI)[12].Among these, the popular and frequently used methods are PTS and SLM techniques for phase optimization as they can obtain better PAPR performance without distortion by generating and selecting the optimum candidate.

2. PAPR IN MIMO-OFDM
An OFDM data block with N subcarriers with $X_k=(X_0,X_1,......,X_{N-1})$, is formed with each symbol modulating the corresponding subcarrier from a set of subcarriers. For MIMO-OFDM system, N=subcarriers chosen to be orthogonal, over the period $0 \le t \le T$ where, T = original data symbol period, and $f_0=1/T$ is the frequency spacing between adjacent subcarriers.The complex baseband OFDM signal for N subcarriers is defined as

$$x(t) = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k e^{j2\pi k f_0 t}, \quad 0 \le t \le T \qquad (1)$$

Replacing $t=nT_b$, where $T_b=T/N$, gives the discrete time version is written as

$$x(t) = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k e^{j2\pi kn/LN}, \quad n=0,1,\ldots, NL-1 \qquad (2)$$

where L = oversampling factor.

The sampling can be implemented by an inverse fast Fourier transform (IFFT)[8]. The PAPR of the transmitted OFDM signal, x(t), is defined as the ratio between the maximum instantaneous power and the average power[13], defined by

$$PAPR = \frac{max_{0 \leq t \leq T} |x(t)|^2}{E[|x(t)|^2]}$$

(3)

where E[・] is the expectation operator .

The theoretical maximum of the PAPR for N number of subcarriers is as follows,

$$PAPR_{max}=10\log(N)\ dB \quad (4)$$

PAPR is a random variable, because it is a function of the input data and the data is random variable. Therefore PAPR can be calculated by using level crossing rate that calculates the average number of times that the envelope of a signal crosses a given level. Knowing the amplitude distribution signals probability of instantaneous amplitude above threshold can be easily calculated and it is applicable for power also. This is performed by calculating complementary cumulative distribution function for different PAPR values as:

$$CCDF=P_r(PAPR>PAPR_0) \quad (5)$$

where P_r=probability value

PAPR=instantaneous value

$PAPR_0$=threshold value

2.1. Multiple Input Multiple Output (MIMO)

In a multipath wireless communication, Multiple Input Multiple Output (MIMO) system leads to the gain of high data rate transmission without increasing the total transmission power or bandwidth. The communication transmission models are single input single output (SISO), single input multiple output (SIMO), multiple input single output (MISO), Multiple input multiple output (MIMO). Multiple-Input Multiple-Output antenna systems are a form of spatial diversity. An effective and practical way to approaching the capacity of MIMO wireless channels is to use space-time block coding in which data is coded through space and time to improve the reliability of the transmission, as redundant copies of the original data are sent over independent fading channels[15].

2.2. Space-Time-Block Codes

Space-time block codes operate on a block of input symbols, producing a matrix output whose columns represent time and rows represent antennas et al [5].Space-time block codes are designed to achieve the maximum diversity order for the given number of transmit and receive antennas and because of this reason space-time block codes a very popular and most widely used scheme. Alamouti scheme is the base of the Space Time Coding technique. Using two transmitting antennas at the transmitter side, a block of two symbols is taken from the source data and transmitted to the modulator. After that, Alamouti space-time encoder takes the two modulated symbols, in this case called s1and s2 creates encoding matrix S where the symbols s1 and s2are mapped to two transmit antennas in two transmit time slots. The encoding matrix using two transmitting antenna is represented as below[2].

$$S = \begin{pmatrix} s_1 & s_2 \\ -s_2^* & s_1^* \end{pmatrix}$$

2.3. Encoding Of STBC for Four Transmitting Antennas

Using four transmitting antennas at the transmitter, for the given symbol period four signals are transmitted simultaneously from four transmit antennas. The signal transmitted from antenna one Tx1 is denoted as s_1, the signal from antenna two (Tx2) by s_2, the signal from antenna three (Tx3) by s_3, and the signal from antenna four (Tx4) by s_4 [5].

Table 1: Encoding of STBC for four transmit antennas

Tx Ant. / Time Slot	Tx1	Tx2	Tx3	Tx4
T	s_1	s_2	s_3	s_4
t+T	$-s_2$	s_1	$-s_4$	s_3
t+2T	$- s_3$	s_4	s_1	$-s_2$
t+3T	$-s_4$	$- s_3$	s_2	s_1
t+4T	s_1^*	s_2^*	s_3^*	s_4^*
t+5T	$-s_2^*$	s_1^*	$-s_4^*$	$- s_3^*$
t+6T	$- s_3^*$	s_4^*	s_1^*	$-s_2^*$
t+7T	$-s_4^*$	$- s_3^*$	s_2^*	s_1^*

2.4. Influencing Factors of PAPR

PAPR is closely related to phase factor, number of sub-blocks, number of sub-carriers and oversampling rate.

2.4.1. Phase factor:-

Partial Transmit Sequence technique is distortion less technique because it divides the frequency vector into number of sub-blocks before applying the phase transformation. In this method, the phase factor parameter is important and the searching process for finding the optimal phase factors. As a result, the signal with lowest PAPR for transmission is chosen from the selected OFDM symbols. In this paper we proposed the new phase factor, W=4 for the PAPR reduction performance[16].

2.4.2. Number of sub-carriers:-

Different number of sub-carrier results in different PAPR performances due to the varying information carried. When the number of sub-carriers increases, the PAPR also increase. Therefore, the number of sub-carrier is a very important influence factor on the PAPR.

2.4.3 Oversampling rate:-

In real implementation, continuous-time OFDM signal cannot be described precisely due to the insufficient N points sampling. Some of the signal peaks may be missed and PAPR reduction performance is unduly accurate. To avoid this problem, oversampling is usually employed, which can be realized by taking L·N point IFFT/FFT of original data with (L-1)· N zero-padding operation. Over-sampling plays an important role for reflecting the variation features of OFDM symbols in time domain.

2.4.4. No. of symbols

In this paper we are discussing PAPR variation by varying no. of subcarriers and symbols.

3. PAPR REDUCTION TECHNIQUES

The PAPR reduction methods are divided into three major categories as Signal distortion techniques, Signal scrambling techniques and Coding techniques. Some powerful schemes are the signal scrambling techniques, contains Selective Level Mapping (SLM) & Partial transmit sequence (PTS) among which PTS is used for the work. In this paper PTS technique is used for reducing PAPR [11].The complexity and computation time is minimum compared to others. In a typical OFDM system with PTS approach several full IFFT operations are avoided in PTS, which is its advantage over SLM .

3.1. Partial Transmit Sequence

The partial transmit sequences algorithm is implemented by dividing the original OFDM sequence into several sub-sequences, and for each sub-sequence is multiplied by different weights until an optimum value is chosen.

3.2. Selected Mapping Algorithm

Selected mapping (SLM) is scrambling technique. It uses to select the data from phase rotated input data block. It selects the most favorable signal (having low PAPR) from a set of phase rotated candidate data blocks generated by transmitter, which are all represent the same information as the original data block. In SLM the transmission of side information is required so that the receiver can use the it to determine which candidate block is selected in the transmission and then recover the information. SLM technique leads additional complexity, and loss in efficiency. However, the PTS PAPR reduction scheme's performance improvement is achieved at the expense of high complexity and difficult parameter setting problems. Therefore, modified PTS indeed use the potential of MIMO transmission for PAPR reduction.

3.3 System Architecture*:*

A block diagram of STBC MIMO-OFDM system with Tx=4 transmit antennas is given below in Figure2.

For system having four transmit antennas, the data symbol vector S=[X_0, X_1 ,…..X_{N-1}] is encoded with space-time encoder into four vectors as follows :

$$S_1=[X_0,-X_1^*,\dots\dots X_{N-2},-X_{N-1}^*]$$

$$S_2=[X_1,X_0^*,\dots\dots X_{N-1},-X_{N-2}^*]$$

$$S_3=\left[X_2,X_{1,}^*X_0,\dots\dots X_{N-1},X_{N-2},X_{N-3}^*\right]$$

$$S_4=\left[X_3,X_{2,}^*X_1,X_0,\dots\dots X_{N-1},X_{N-2},X_{N-3,}X_{N-4}^*,\right]$$

Symbol S1 and S2 represent the two neighboring OFDM signals in time domain.Serial input data first passes through the serial to parallel converter. Then the parallel signal is mapped with QPSK modulation to generate the data block S. It is further partitioned into V disjoint subblocks S1, S2, ... ,Sv . A subblock Sm (m=l, 2, ... , V) is mapped into a set of symbol sequences, which are fed to the IFFT blocks and sent simultaneously from antennas Tx1, Tx2, Tx3 and Tx4 respectively[14].

1. All subcarriers positions which are occupied in another sub-block are set to zero. Each of the blocks, has an IFFT performed on it.
2. The output of each block except for first block which is kept constant, is phase rotated by the rotation factor as given by

$$e^{j\theta\,(v)}\epsilon[0,2\pi]$$

3. The blocks are then added together to produce alternate transmit signals.
4. Each alternate transmit signal is stored in memory and the process is repeated again with a different phase rotation value. After a set number of phase rotation values.
5. The weighting rotation parameter set is chosen to minimize the PAPR. The computational complexity of PTS method depends on the number of phase rotation factors allowed.
6. After addition of all the sub-blocks, select the sequence with minimum PAPR.
7. To increase the potential capability of PAPR reduction performance for the PTS method, these phase factors combination correctly maintains the orthogonality between the different modulated carriers.
8. However, the PTS PAPR reduction scheme's performance improvement is achieved at the expense of high complexity and difficult parameter setting problems. Therefore, modified PTS indeed use the potential of MIMO transmission for PAPR reduction[9].

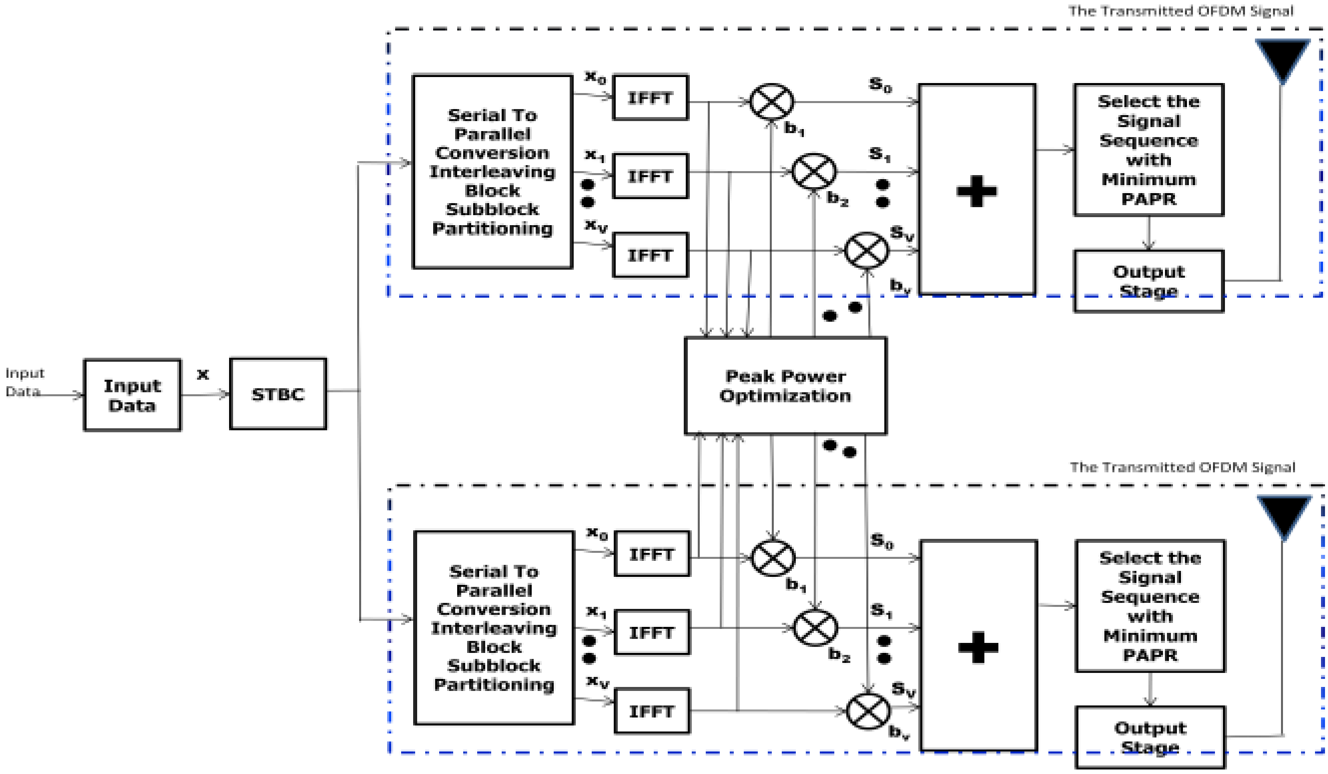

Fig.2 Block diagram of STBC MIMO-OFDM system with Tx=4 transmit antennas

4. RESULTS AND DISCUSSION

To evaluate the performance of modified PTS technique for different number of transmitting antennas, we simulate it using MATLAB 7.12. PAPR reduction performance depends on the number of subcarriers N and the number of OFDM symbols. In this paper we study the effects of subcarriers and OFDM symbols.

Table 2: Parameters used in simulation

Information	Parameters
Modulation	QPSK
Number of subcarriers(N)	64,128,256,512
Number of OFDM symbols(U)	4,8,16
Number of sub-blocks(V)	4
Number of transmitting antenna(Tx)	2,4
Number of phase factor(W)	2,4

Fig. 3(a) and fig.3(b) display the PAPR reduction using modified PTS method with different subcarrier, in which modulation scheme, QPSK is applied, V=4 and W=4, W=2. From this figure it is observed that PAPR reduction for N=64, N=128, N=256, N=512, very small for W=2 and results are same for W=4.

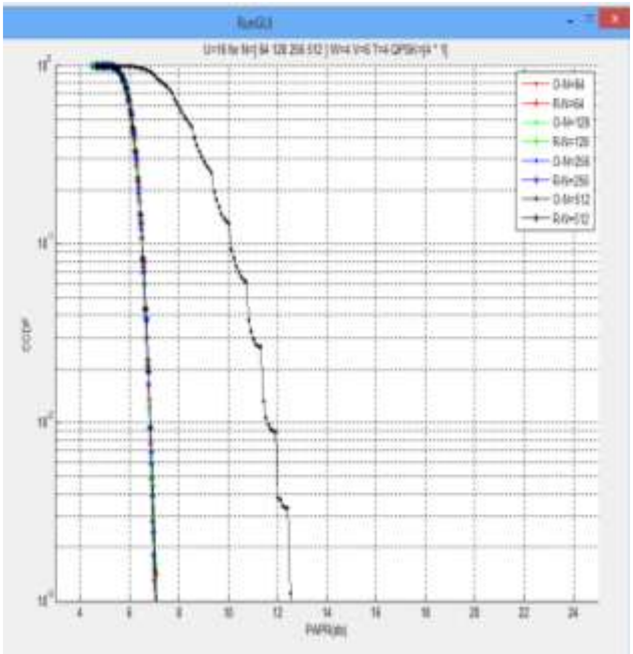

Fig.3(a) CCDF of PAPR for QPSK modulation using different subcarriers when V=4,W=4 with Tx=4 transmit

antenna.

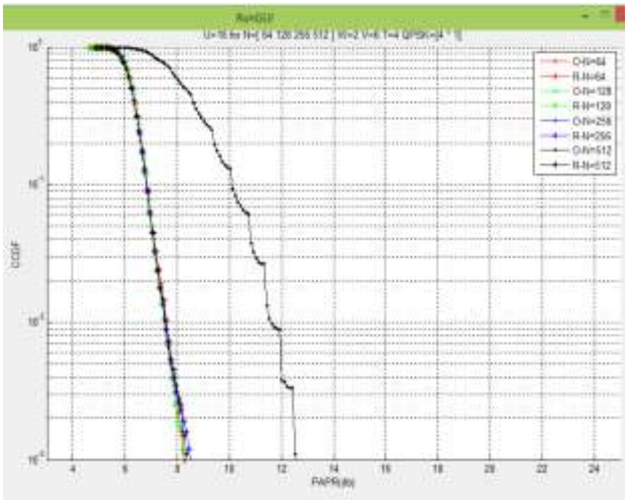

Fig.3(b) CCDF of PAPR for QPSK modulation using different subcarriers when V=4,W=2 with Tx=4 transmit antenna.

Table 3: Reduced PAPR for different subcarriers

Modulation scheme	Fixed parameter	Variable parameter	Reduced PAPR in dB	
			W=2	W=4
QPSK	U=16	N=64	8.2dB	7.2dB
		N=128	8.2dB	7.2dB
		N=256	8.4dB	7.2dB
		N=512	8.4dB	7.2dB

Fig. 4(a) and fig.4(b) displays PAPR reduction for QPSK modulation using different OFDM symbol using four transmitting antenna and V=4, W=4 and W=2. Figure shows the reduction in PAPR according to the OFDM symbol candidate increases.

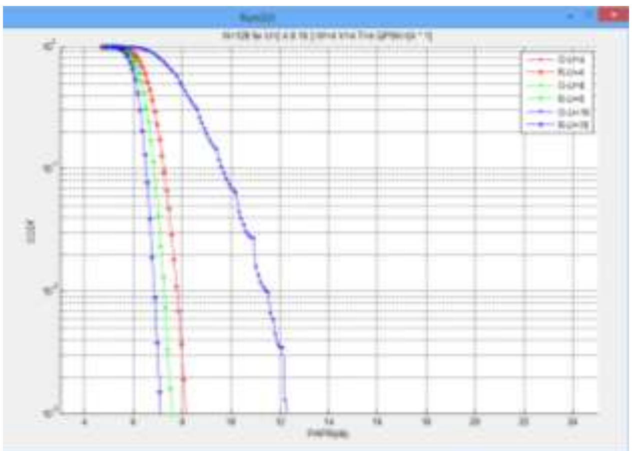

Fig.4 (a)CCDF of PAPR for QPSK modulation use in different OFDM symbols when V=4, W=4 with Tx=4 ransmit antenna.

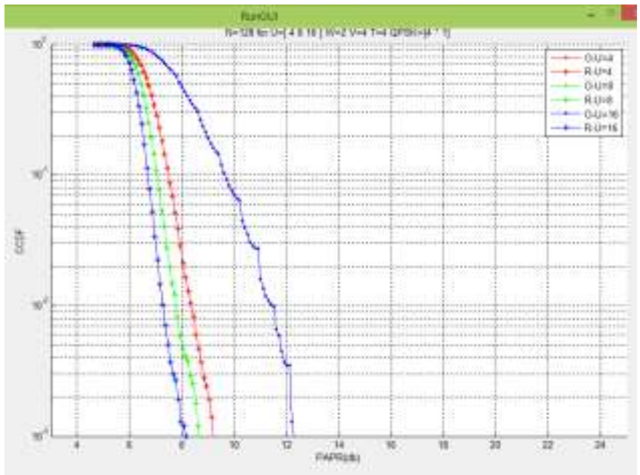

Fig.4 (b)CCDF of PAPR for QPSK modulation use in different OFDM symbols when V=4, W=2 with Tx=4 transmit antenna.

Table 4: Reduced PAPR for number of symbols

Modulation scheme	Fixed parameter	Variable parameter	Reduced PAPR in dB	
			W=2	W=4
QPSK	N=128	U=4	9.2dB	8.1dB
		U=8	8.8dB	7.8dB
		U=16	8.2dB	7.2dB

In Fig. 5(a) and fig.5(b) it is shown that CCDF of PAPR for Tx=2 and Tx=4 with V=4, W=4, W=2, N=128,U=16 and QPSK modulation are improved. Figure shows PAPR reduction performance improvement for W=4.

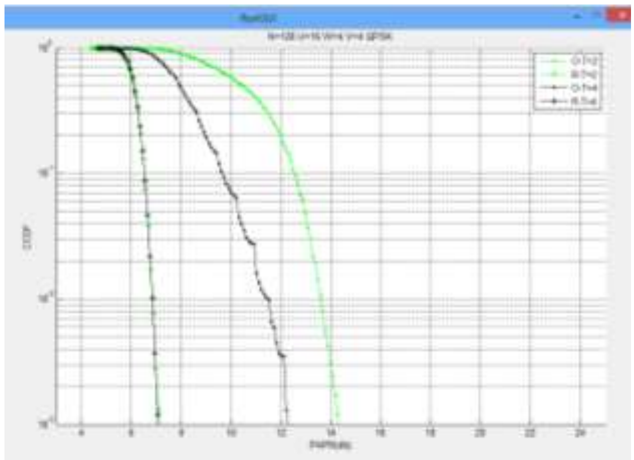

Fig.5(a) CCDF of PAPR for Tx=2 verses Tx=4 using QPSK modulation when V=4 with N=128,W=4.

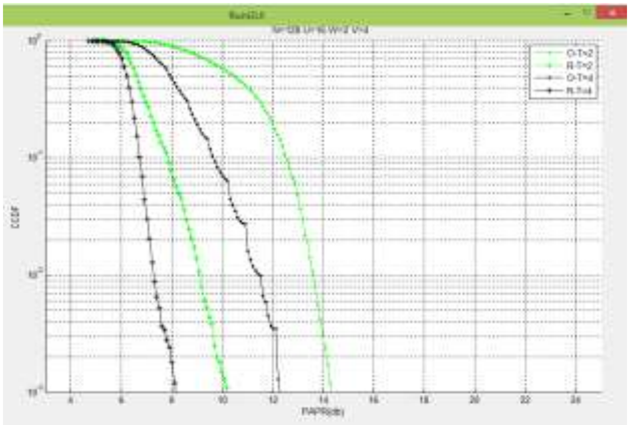

Fig.5(b) CCDF of PAPR for Tx=2 verses Tx=4 using QPSK modulation when V=4 with N=128,W=2.

Table 5: Reduced PAPR for two and four transmitting antennas(Tx2 and Tx4)

Modulation scheme	Fixed parameter	Variable parameter	Reduced PAPR in dB	
			W=2	W=4
QPSK	N=128	Tx=2	10.1dB	7dB
		Tx=4	8.1dB	7dB

5. CONCLUSION

In multicarrier communication system, Orthogonal Frequency Division Multiplexing is used as signal modulation and demodulation technique. OFDM has the advantage of high spectrum efficiency and channel robustness, it is used in high speed communication. But high PAPR is the major drawback of OFDM system which will distort the transmitted signal at the receiver. The PTS provides a distortion less technique in eliminating the PAPR at the expense of additional complexity. In this paper, the analysis of PAPR reduction is based on varying the number of subcarriers and OFDM symbols for a new phase factor. The simulation results showed PAPR reduction for phase factor W=4 than that of phase factor W=2. PAPR reduction is observed when OFDM symbols increased from 4,8 to 16. For number of symbols 16 the PAPR reduction is maximum than number of symbols 4 and 8. Increase in number of symbols results in reduction in PAPR, but this increases BER.

6. REFERENCES:

[1] Jing Gao, Jinkuan Wang and Yun Wang, "A low complexity PAPR reduction technique for STBC MIMO-OFDM SYSTEM", in Proceedings of International Conference on Wireless Communications, Networking and Mobile Computing, Shanghai, 21-25 September 2007.

[2] S. M. Alamouti, "A simple transmitter diversity scheme for wireless communications," IEEE J. Select. Areas Commun., vol. 16, pp. 1451–1458, Oct. 1998.

[3] R. V. Nee and R. Prasad, OFDM for Wireless Multimedia Communications, London, Artech House, 2000.

[4] Simon Haykin, Digital Communication, chapter 8, Wiley publishers, 1988.

[5] Santumon.S.D and B.R. Sujatha "Space-Time Block Coding (STBC) for Wireless Networks"in International Journal of Distributed and Parallel Systems (IJDPS) Vol.3, No.4, July 2012.

[6] Z.Xiuyan and T.Guobin, "The research of improved PTS method for peak-to -average power ratio reduction", in Proceedings of 3rd international conference on wireless. mobile and multimedia networks, Beijing, China, 26-29 September 2010.

[7] R. Baumal, R. Fischer, and J. Huber, ―Reducing the peak-to-average power ratio of multicarrier modulation by selective mapping,‖IEEE Electronics Letters, vol. 32, no. 22, pp. 2056-2057, October 1996.

[8] S. H. Han, J. H. Lee, "An Overview of Peak – to – Average Power Ratio Reduction Techniques for Multicarrier Transmission", IEEE Transaction on Wireless Communication, April 2005.

[9] P . Mukunthan and P Dananjayan, "PAPR Reduction based on a Modified PTS with Interleaving and Pulse Shaping method for STBC MIMO-OFDM System", IEEE conference publication on ICCCNT 2012.

[10] D. Phetsomphou, S.Yoshizawa, and Y Miyanaga, "A partial transmit sequence technique for PAPR reduction in MIMO-OFDM systems", in Proceedings of 10th international Symposium on Communications and Information Technologies, Tokyo, Japan, pp. 672-67 6, 26-29 October 2010.

[11] L.J.Cimini and N. R. Swollen berger, "Peak-to-average-power ratio reduction of an OFDM signal using partial transmit sequences," IEEE commun. Lett. Vol. 4, no. 3, March 2000.

[12] C.Tellambura, ―Phase optimization criterion for reducing peak-toaverage power ratio of an OFDM signal,‖IEEE Electronics Letters,. vol. 34, no. 2, pp. 169-170, January 1998.

[13] Xinchun Wu, Zhigang Mao, Jin xiang Wang, Bin Zho., " A novel PTS technique with combinative optimization in real part and imaginary part for PAPR reduction in OFDM systems", in Proceedings of Third International Conference on Next Generation Mobile Applications, Services and Technologies, Cardiff, Wales, UK, 15-18 September 2009.

[14] Shilpa A. Talele,Aarti G. Ambekar,Deepshikha Hinger," Novel PTS Technique to PAPR Reduction for STBC MIMO-OFDM using Four Transmitting Antennas", IJCA Proceedings on International Conference on Computer Technology 2015(1):25-30, September 2015.

[15] A. J. Paulraj al., " An Overview of MIMO Communications—A Key to Gigabit Wireless,"Proc. IEEE vol.92 no. 2, Feb. 2004.

[16] Amrutha.V.Nair, T.Sudha,"A low complexity partial transmit sequence scheme for better papr reduction in ofdm systems,"International journal of research in Engineering and Technology, Vol. 02, issue 10, oct. 2013.