Alamouti STBC MIMO OFDM System using ZCT Precoded Based SLM Technique for PAPR Reduction

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Abstract—**OFDM system is combined with multiple-input multiple-output (MIMO) in order to increase the system capacity and diversity gain. However, one of the major drawback of MIMO-OFDM have high peak-to-average power ratio (PAPR) in order to the signals transmittted on different antennas. In this paper, we propose Zadoff-Chu matrix Transform (ZCT) precoding based Selected Mapping (SLM) technique to reduce the peak-to-average power ratio (PAPR) in Alamouti STBC MIMO-OFDM systems. The key idea of this paper is that different phase rotation sequences are multiplied by their corresponding input sequence generated by the STBC encoder at the transmitter and precoding the symbols with ZCT precoder and the lowest PAPR is selected for transmission. To reduce the high PAPR, BPSK modulation techniques is used for N=128. Our proposed work shows that ZCT-SLM based MIMO-OFDM system using Alamouti STBC has the lowest PAPR performance compared to conventional ZCT-SLM based OFDM system. MATLAB simulation shows that the performance of the proposed algorithm significantly improves the PAPR reductions.**

Index Terms— **MIMO, OFDM, PAPR, STBC, SLM, ZCT.**

I. INTRODUCTION

Orthogonal frequency division multiplexing (OFDM) is modulation and multiplexing technology, developed to meet the increasing demand for higher data rates in communication. Multi-carriers (MC) modulation is the key concept of OFDM technique. It also improves the bandwidth efficiency and increases system capacity so as to provide a reliable transmission [1]. An arrangement of using multiple antennas at transmitter and receiver of OFDM system is called as (MIMO-OFDM) multiple input multiple output OFDM. MIMO-OFDM system is based on wireless technology in which we transfer more data at same time by using multiple transmitters and multiple receivers. MIMO-OFDM improves the data rate (bits per second) and quality of signals so that the better quality of service can be achieved. MIMO-OFDM system takes advantages of multipath interference effect to increase user and data capacity. In multicarrier system, there are different subcarriers that may be out of phase with each other and that subcarrier may be having extreme amplitude that passes through the transmitted signal. Due to multicarrier system, the peak value of system can be as high as compare to average value of whole system. This ratio of peak to average power value is called as Peak to average power (PAPR).This is very big issue in MIMO-OFDM system. This high PAPR causes in-band distortion and out-of-band radiation and reduce bit-error rate due to nonlinearity effects [2]. There are many techniques used to reduce the peak to average power ratio of MIMO-OFDM system that are Clipping and filtering [3], Partial transient sequence (PTS) [4], Selected mapping(SLM) [5], Zadoff-Chu transform (ZCT) [6]. Zadoff-Chu sequence provides constant amplitude output signal with optimum correlation properties and reducing the cost and complexity of output signal.

In this paper, we propose to use the property of space-time block coded (STBC) in Alamouti MIMO-OFDM systems. The main idea of Alamouti STBC MIMO-OFDM system is that the conjugate symbols transmitted on two antennas that have same property. We use ZCT-SLM technique for PAPR reduction in Alamouti STBC MIMO OFDM system and compare our result with ZCT- SLM based OFDM system. The lowest PAPR signal will be selected for transmission from a number of different data blocks (independent phase sequences) that have the same information at the transmitter. And shows that the performance of the proposed algorithm outperforms the conventional concurrent algorithms.

The organization of the article is as follows: Section II outlines the data model of the OFDM systems and the PAPR reduction by SLM and ZCT algorithm. Section III explains the ZCT-SLM based OFDM system. Data model of the Alamouti STBC MIMO-OFDM systems, PAPR reduction by SLM and ZCT algorithm and the PAPR property of the conjugate symbols transmitted on two antennas are proved in Section IV. The proposed system model for PAPR reduction in ZCT- SLM based Alamouti STBC MIMO OFDM system is discussed in Section V. In Section VI presents the simulation result of comparison between ZCT-SLM based Alamouti STBC MIMO-OFDM system with the

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ZCT-SLM based OFDM system and section VII describes the conclusion.

II. OFDM SYSTEM AND PAPR

A. Conventional OFDM

Fig.1 shows the block diagram of conventional OFDM system In OFDM System initially the binary data is modulated using modulation technique or mapper and it is converted to the parallel order which is mainly used to reduce complexity of the signal $X = [X_0, X_1, \ldots\ldots X_{N-1}]^T$. The modulated output X is of complex vector of order N (where N is sub carriers) is passed to the Inverse Fast Fourier Transform, X is then passed through the IFFT block. The complex modulated baseband OFDM signal with N subcarriers can be written as:

$$x_n(t) = \frac{1}{\sqrt{N}} \sum_{m=0}^{N-1} X_m \exp\left(\frac{j2\pi mt}{NT}\right), \quad 0 \le t \le NT \quad (1)$$

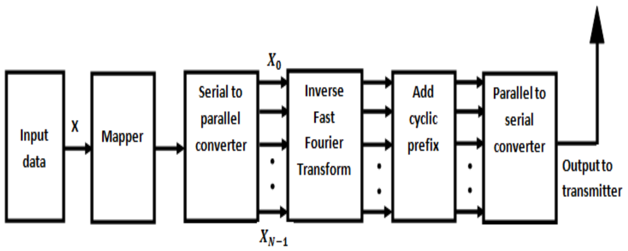

Fig. 1. Block diagram of Conventional OFDM system

The IFFT converts the modulated complex data to the time domain which reduces the complexity of the system and improves the fastness of the Algorithm. One of the main disadvantages of OFDM systems is the high PAPR of transmitted signal due to the combination of N modulated subcarriers. The PAPR is the relation between the maximum powers of a sample in a given OFDM transmit symbol divided by the average power of that OFDM symbol. Presence of large number of independently modulated sub-carriers in an OFDM system the peak value of the system can be very high as compared to the average of the whole system. The ratio of the peak power to average power is termed as Peak-to-Average Power Ratio. The PAPR of an OFDM symbol is defined as:

$$PAPR = \frac{\max_{0 \le t \le NT} |x_n(t)|^2}{E[|x_n(t)^2|]} \quad (2)$$

Where N is the number of subcarriers in each symbol and 1/ NT =Δf is the subcarrier spacing chosen to make them orthogonal. Where E[.] denotes expectation and the Complementary Cumulative Distribution Function(CCDF) for an OFDM signal can be written as:

$$CCDF == 1 - (1 - e^{-PAPR_0})^N \quad (3)$$

B. Zadoff-Chu Sequences and Zadoff-Chu Transform

Zadoff-Chu sequences are class complex-valued sequence and having optimum correlation properties [8]. Zadoff-Chu sequences have constant magnitude and an ideal periodic autocorrelation. Mathematically, Zadoff–Chu sequences can be defined for a sequence of length L as:

$$a_n = \begin{cases} e^{\frac{j2\pi r}{N}\left(\frac{k^2}{2} + qk\right)} & \text{for } N \text{ even} \\ e^{\frac{j2\pi r}{N}\left(\frac{k(k+1)}{2} + qk\right)} & \text{for } N \text{ odd} \end{cases} \quad (4)$$

Where$k = 0,1, \ldots\ldots, N-1$, q is any integer, r is any integer relatively prime to N and j=$\sqrt{-1}$. Zadoff-Chu matrix transform (A) is of size $N = L \times L$ is obtained by reshaping the ZC sequence with $k = m + lL$ as written below:

$$A = \begin{bmatrix} a_{00} & a_{01} & \cdots & a_{0(L-1)} \\ a_{10} & a_{11} & \cdots & a_{1(L-1)} \\ \vdots & \vdots & \ddots & \vdots \\ a_{(L-1)0} & a_{(L-1)1} & \cdots & a_{(L-1)(L-1)} \end{bmatrix} \quad (5)$$

C. ZCT Based OFDM (ZCT-OFDM) System

Fig.2 shows the block diagram of ZCT based OFDM system. In the ZCT, the baseband modulated data is passed through S/P convertor which generates a complex vector of size N that can be written as $X = [X_0, X_1, \ldots\ldots X_{L-1}]^T$. Then ZCT precoding A is applied to this complex vector which transforms this complex vector into new vector of same length L. This new vector, of length L transformed by ZCT precoding can be written as:

$$Y = AX = [Y_0, Y_1, \ldots., Y_{L-1}]^T \quad (6)$$

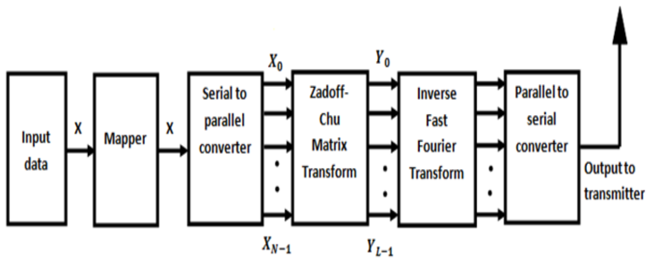

Fig. 2. Block diagram of ZCT based OFDM system

Where A is a precoder matrix of N=L*L and Y_m can be written as:

$$Y_m = \sum_{l=0}^{L-1} a_{m,l} \cdot X_l, \quad m = 0,1, \ldots., L-1 \quad (7)$$

$a_{m,l}$ means m^{th} row and l^{th} column of precoder matrix. Expanding above equation using row wise sequence reshaping $k = mL+l$ and putting q = 0, r = 1 we get

$$Y_m = \sum_{l=0}^{L-1} \left(e^{j\frac{\pi(mL+l)^2}{L^2}}\right) \cdot X_l$$

$$= e^{j\pi m^2} \sum_{l=0}^{L-1} \left(\left(e^{j\frac{\pi l^2}{L^2}} \cdot X_l\right) \cdot e^{j\frac{2\pi ml}{L}}\right) \quad (8)$$

Where $m = 0, 1, 2, \ldots, L-1$ these represents the ZCT precoded constellations symbols. The complex baseband ZCT OFDM signal with subcarriers without precoding is given by:

$$x_n = \frac{1}{\sqrt{L}} \sum_{m=0}^{L-1} Y_m \, e^{j2\pi\frac{n}{L}m}, \quad n = 0,1, \ldots, L-1 \quad (9)$$

The PAPR of ZCT OFDM signal can be written as:

$$PAPR = \frac{\max |x_n|^2}{E[|x_n|^2]} \quad (10)$$

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D. SLM Based OFDM (SLM-OFDM) System

Selected Mapping Techniques indicates that one of the sequences has to be selected out of a number of sequences. This is one of the most promising reduction techniques to reduce Peak to Average Power Ratio (PAPR) of Orthogonal Frequency Division Multiplexing (OFDM) system. The main idea of this technique is based on the phase rotation and to generate a set of U different data blocks at the transmitter side which represent the original information and then to select the minimum PAPR for transmission. Let us consider an OFDM system with N number of subcarrier to be used.

Fig.3 shows the block diagram of SLM based OFDM system. Assuming the input data X_n is passed through mapper where the data is modulated through modulation techniques that to be used. After serial to parallel conversion $X_n = [X_0, X_1, \ldots. X_{N-1}]^T$ multiplied with independent phase sequences $S_n^{(u)} = [S_0^{(u)}, S_1^{(u)}, \ldots, S_{N-1}^{(u)}]^T$ where $u = 1,2,\ldots,U$ and $n = 0,1,\ldots,N-1$. The u^{th} candidate vector that is generated by the multiplication of data block with the phase vector is denoted as $X_n^{(u)}$ the equation can be written:

$$X_n^{(u)} = [X_0\ S_0^{(u)}, X_1\ S_1^{(u)}, \ldots\ldots, X_{N-1}\ S_{N-1}^{(u)}]^T$$

$$X_n^{(u)} = X_n \,.\, S_n^{(u)} \qquad (11)$$

After multiplication $X_n^{(u)}$ is passed through IFFT where each sequence convert the frequency domain signal in to time domain signal. After IFFT operation we will obtain U number of alternative OFDM signals that can be written mathematically as:

$$x_n^{(u)} = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} X_n^{(u)}\, e^{j2\pi n \Delta f t} \quad , \qquad 0 \le t \le T \qquad (12)$$

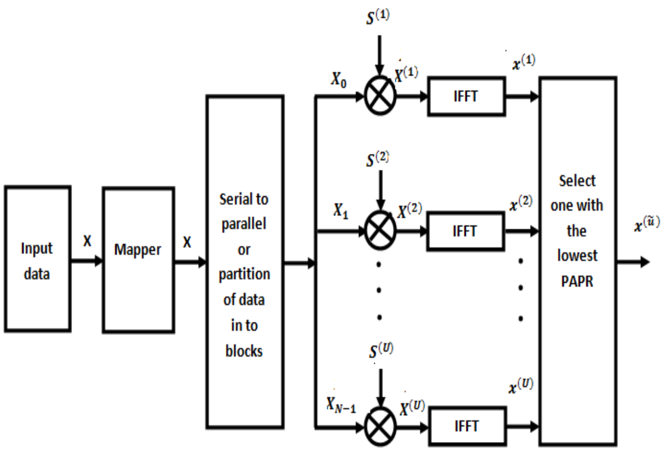

Fig. 3. Block diagram of SLM based OFDM system.

Where T is the symbol duration and $\Delta f = 1/T$. Finally comparing the PAPR among the independent data blocks and the OFDM signals with the lowest PAPR will be selected for transmission. Let $x^{(\tilde{u})}$ has the lowest PAPR and selected for transmission and the equation can be expressed as:

$$x^{(\tilde{u})} = argmin_{0 \le u \le U}\,[PAPR(x^{(u)})] \qquad (13)$$

Where argmin ( ) represents the argument of minimum value.

III. ZCT - SLM BASED OFDM (ZCT-SLM-OFDM) SYSTEM

Fig.4 shows the block diagram of ZCT-SLM based OFDM system. The input data stream X is passed through mapper after serial to parallel conversion the data become $X_l = [X_0, X_1, \ldots. X_{L-1}]^T$ and is multiplied with independent phase sequences $S_l^{(u)} = [S_0^{(u)}, S_1^{(u)}, \ldots, S_{L-1}^{(u)}]^T$ where $u = 1,2,\ldots,U$. The u^{th} candidate vector that is generated by the multiplication of data block with the phase vector can be defined as $X_l^{(u)}$.

$$X_l^{(u)} = [X_0\ S_0^{(u)}, X_1\ S_1^{(u)}, \ldots\ldots, X_{L-1}\ S_{L-1}^{(u)}]^T$$

$$X_l^{(u)} = X_l \,.\, S_l^{(u)} \quad , \quad 1 \le u \le U \qquad (14)$$

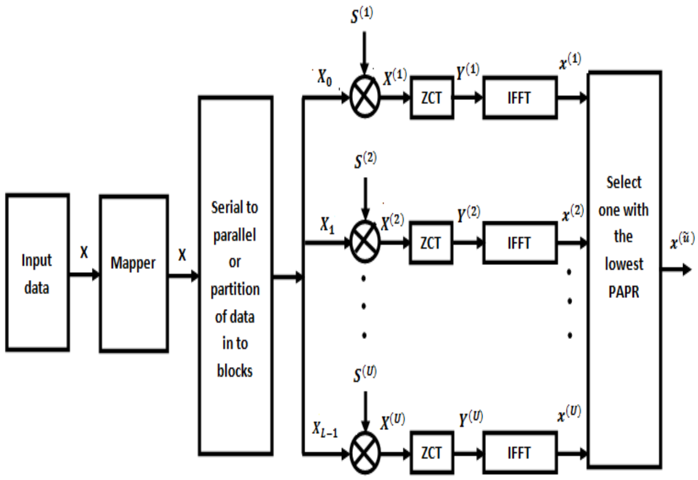

Fig. 4. Block diagram of ZCT-SLM based OFDM system.

Now we pass the signal given in Eq. (14) through ZCT precoder and the resulting signal $Y_m^{(u)}$ can be written as:

$$Y_m^{(u)} = \sum_{l=0}^{L-1} a_{m,l}\ .X_l^{(u)} \quad , \ m = 0,1,\ldots,L-1 \qquad (15)$$

$a_{m,l}$ means m^{th} row and l^{th} column of the precoding ZCT matrix. After performing the IFFT operation the signal in Eq. (15) can be written as:

$$x_n^{(u)} = \frac{1}{\sqrt{L}} \sum_{m=0}^{L-1} Y_m^{(u)} e^{j2\pi \frac{n}{L} m} \quad , \ n = 0,1,\ldots,L-1 \qquad (16)$$

PAPR of ZCT-SLM-OFDM signal in Eq. (16) can be written as:

$$PAPR = \frac{\max |x_n^{(u)}|^2}{E[|x_n^{(u)}|^2]} \qquad (17)$$

IV. MIMO OFDM SYSTEM AND PAPR

A. Alamouti STBC MIMO-OFDM System

Fig.5 illustrates the basic block diagram of a Alamouti STBC MIMO-OFDM system. The input data is passed through mapper which modulates the signal. Modulated baseband symbols are passed through serial-to-parallel (S/P) converter which generates complex vector of size *N* and can be expressed as $S_k = [S_1, S_1, \ldots, S_N]^T$. Complex vector S_k is then passed through the space time block code encoder which generates two sequences for 1st and 2nd antenna respectively

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$$S_1 = [s_1, -s_2^*, s_3, -s_4^*, \dots\dots\dots\dots, s_{N-1}, -s_N^*] \quad (18)$$

$$S_2 = [s_2, s_1^*, s_4, s_3^*, \dots\dots\dots\dots, s_N, s_{N-1}^*] \quad (19)$$

Where S_k be the transmitted modulated MIMO OFDM symbol of the i^{th} transmitting antenna at the k^{th}subcarrier. Both of these sequences are then passed through each IFFT block for antenna 1 and antenna 2 respectively which convert the frequency domain signal in to time domain signal which is converted into parallel form by using S/P Converter, then we will perform its IFFT. The Output of IFFT gives the time domain MIMO-OFDM symbols, which are converted into serial data streams through P/S converter. The Cyclic Prefix (CP) or Guard Interval is a periodic extension of the last part of an OFDM symbol that is added to the front of the symbol in the transmitter. Finally the output of CP is passes through the transmitter with different transmission period. Alamouti MIMO OFDM signal for antenna *i* can be written as:

$$s_i(t) = \frac{1}{\sqrt{N}} \sum_{k=1}^{N} S_m(k) e^{j2\pi f_n t} \quad (20)$$

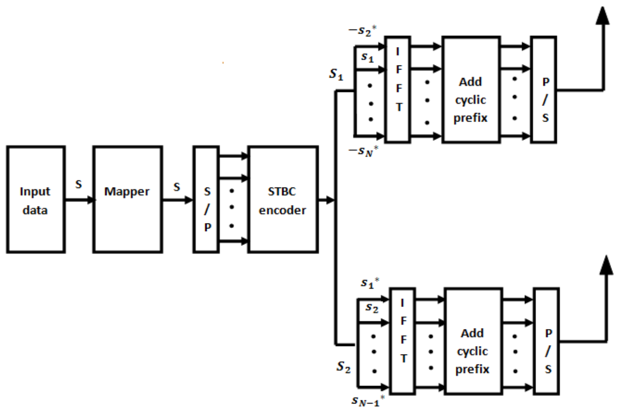

Fig. 5. Block diagram of Alamouti STBC MIMO- OFDM system.

Where $f_n = n\Delta f$, n = 1,2,……, N, where $\Delta f = \frac{1}{NT}$, T is the symbol period and $k = 1,2,,\dots\dots, N, i = 1,2$ and $j = \sqrt{-1}$ Eq. (20) become as:

$$s_i(t) = \frac{1}{\sqrt{N}} \sum_{k=1}^{N} S_i(k) e^{j2\pi n \frac{1}{NT} t} \quad (21)$$

The PAPR of the signal $s_i(t)$ is defined as the ratio of the peak instantaneous power to average power of an OFDM symbol is written as:

$$PAPR = \frac{\max_{0\le t\le NT} |s_i(t)|^2}{E[|s_i(t)^2|]} \quad (22)$$

Where E[·] is the expectation operator. Complementary Cumulative Distribution Function (CCDF), calculate the probability of PAPR of an OFDM signal exceeds a given threshold. In MIMO OFDM, the probability of MN-OFDM symbol over all M transmit antenna as:

$$CCDF = Prob[PAPR > PAPR_0]$$
$$= 1 - (1 - e^{-PAPR_0})^{MN} \quad (23)$$

B. ZCT Based Alamouti STBC MIMO OFDM (ZCT-MIMO-OFDM) System

Fig.6 shows the block diagram of ZCT based Alamouti STBC MIMO OFDM system. In the ZCT based Alamouti STBC MIMO-OFDM system, the modulated data is passed through the S/P converter which generates a complex vector of size *N* that can be written as $S_k = [S_1, S_2, \dots, S_L]^T$. The complex vector S_k is passed through STBC encoder which generates two sequences, for antenna 1and 2 S_1 and S_2 are generated.

$$S_1 = [s_1, -s_2^*, s_3, -s_4^*, \dots\dots\dots\dots, s_{L-1}, -s_L^*] \quad (24)$$

$$S_2 = [s_2, s_1^*, s_4, s_3^*, \dots\dots\dots\dots, s_L, s_{L-1}^*] \quad (25)$$

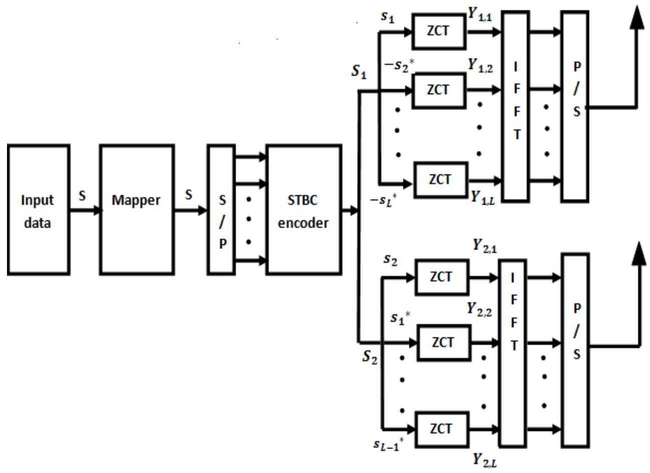

Fig.6. Block diagram of ZCT based Alamouti STBC MIMO- OFDM system

These two generated sequences are then applied to the Zadoff- Chu Transform in this system, *A* matrix of dimension *N* = *A* × *A* is applied to the symbols after the STBC encoding then IFFT is used to reduce the PAPR. Subsequently, ZCT matrix is applied to this complex vector which transforms this complex vector into a new vector of length *L* that can be written as, $Y = AS_i = [Y_0, Y_1, \dots, Y_{L-1}]^T$, where *A* is ZCT matrix of size *N* = *L* × *L* and $Y_{m,i}$ can be written as:-

$$Y_{i,m} = \sum_{l=1}^{L} a_{m,l} \,.\, S_{i,l} \;,\quad m = 1,2,\dots, L \text{ and } i = 1,2 \quad (26)$$

$a_{m,l}$ means m^{th} row and l^{th} column of precoder matrix. Expanding Eq.(26), using row wise sequence $k = mL + l$ and putting $q = 0$ and $r = 1$ in Eq.(4) we get:

$$Y_{i,m} = \sum_{l=1}^{L} \left(e^{j\frac{\pi(mL+l)^2}{L^2}} \right) . S_{i,l} \quad (27)$$

The complex baseband ZCMT Alamouti MIMO OFDM signal for antenna I with N subcarriers can be written as:

$$s_{i,n} = \frac{1}{\sqrt{L}} \sum_{m=1}^{L} Y_{i,m}\, e^{j2\pi\frac{n}{L}m} \quad , \quad n = 1,2 \dots, L \quad (28)$$

The PAPR of ZCT OFDM signal can be written as:

$$PAPR = \frac{\max |s_{i,n}|^2}{E[|s_{i,n}|^2]} \quad (29)$$

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C. SLM Based Alamouti STBC MIMO OFDM (SLM-MIMO-OFDM) System

Fig.7 shows the block diagram of SLM based Alamouti STBC MIMO OFDM system. Assuming that that the input sequences S_k is passed through mapper where it is modulated with BPSK modulation. After serial to parallel conversion it generates a complex vector of size N as$S_k = [S_1, S_1, \ldots, S_N]^T$ These data is then passed through STBC encoder where it generates two sequences, for antenna 1 $S_1 = [s_1, -s_2^*, \ldots s_{N-1}, -s_N^*]$ and for antenna 2 $S_2 = [s_2, s_1^*, \ldots, s_L, s_{L-1}^*]$ is generated. These sequences are multiplied with U different phase sequence vector $B_i^{\,u} = [B_1^{(u)}, B_2^{(u)}, \ldots B_N^{(u)}]$ where $i = 1,2$ and$u = 1,2, \ldots, U$. After multiplication the output of the phase sequence vector for antenna 1 and antenna 2can be written as:

$$S_1^{(u)} = [S_1 B_1^{(u)}, -S_2^* B_2^{(u*)}, \ldots, -S_N^* B_N^{(u*)}] \qquad (30)$$

$$S_2^{(u)} = [S_2 B_2^{(u)}, S_1^* B_1^{(u*)}, \ldots, B_{N-1}^{(u*)}] \qquad (31)$$

$$S_i^{(u)} = S_i B_i^{(u)} \qquad (32)$$

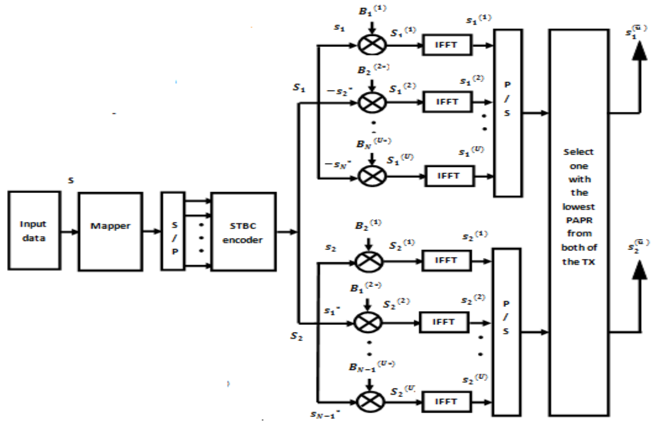

Fig.7. Block diagram of SLM based Alamouti STBC MIMO- OFDM system

Eq.(32) is then passed through IFFT where the frequency domain signal is converted into time domain signal:

$$s_{i,k}^{(u)} = \frac{1}{\sqrt{N}} \sum_{k=1}^{N} S_{i,k}^{(u)} e^{j\frac{2\pi mk}{N}} \qquad (33)$$

PAPR of SLM based Alamouti STBC MIMO OFDM system can be expressed as:

$$PAPR = \frac{\max |s_{i,k}^{(u)}|^2}{E[|s_{i,k}^{(u)}|^2]} \qquad (34)$$

Minimum PAPR of the two signals is chosen as.

$$s_i^{(\tilde{u})} = \arg \min_{1 \le u \le U} (\max_{m=1,2} \max_{1 \le n \le N} |\, s_{i,k}^{(u)}|) \qquad (35)$$

V. PROPOSED MODEL: ZCT- SLM BASED ALAMOUTI STBC MIMO OFDM (ZCT-SLM-MIMO-OFDM) SYSTEM

Fig.8 shows the block diagram of ZCT-SLM based Alamouti STBC MIMO OFDM system. Input data S_l is passed through mapper and serial to parallel conversion. After S/P the data become $S_l = [S_1, S_2, \ldots S_L]^T$it is then passed through STBC encoder which generate $S_1 = [s_1, -s_2^*, \ldots s_{N-1}, -s_N^*]$ for antenna 1 and $S_2 = [s_2, s_1^*, \ldots, s_L, s_{L-1}^*]$ for antenna 2 respectively. Both of these are multiplied with independent phase sequences $B_i^{\,u} = [B_1^{(u)}, B_2^{(u)}, \ldots B_L^{(u)}]$ where $i = 1,2$ and $u = 1,2, \ldots, U$. The u^{th} candidate vector that is generated by the multiplication of data block with the phase vector can be defined as $S_l^{(u)}$.

$$S_1^{(u)} = [S_1 B_1^{(u)}, -S_2^* B_2^{(u*)}, \ldots, -S_L^* B_L^{(u*)}] \qquad (36)$$

$$S_2^{(u)} = [S_2 B_2^{(u)}, S_1^* B_1^{(u*)}, \ldots, S_{L-1}^* B_{L-1}^{(u*)}] \qquad (37)$$

$$S_{i,l}^{(u)} = S_{i,l} B_{i,l}^{(u)} \qquad (38)$$

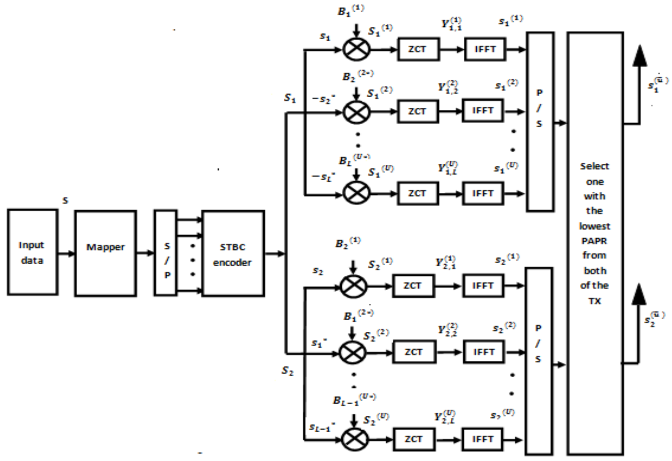

Fig.8. Block diagram of ZCT-SLM based Alamouti STBC MIMO- OFDM system

Now we pass the signal given in Eq. (38) through ZCT precoder and the resulting signal $Y_{i,m}^{(u)}$ can be written as:

$$Y_{i,m}^{(u)} = \sum_{l=1}^{L} a_{m,l} \,.\, S_{i,l}^{(u)} \qquad (39)$$

$a_{m,l}$ means m^{th} row and l^{th} column of the precoding ZCT matrix. After the IFFT operation the signal in Eq. (39) can be written as:

$$s_{i,n}^{(u)} = \frac{1}{\sqrt{L}} \sum_{m=1}^{L} Y_{i,m}^{(u)} e^{j2\pi\frac{n}{L}m} \quad , \quad n = 1,2 \ldots, L \qquad (40)$$

PAPR of ZCT-SLM-OFDM signal in Eq. (40) can be written as:

$$PAPR = \frac{\max |s_{i,n}^{(u)}|^2}{E[|s_{i,n}^{(u)}|^2]} \qquad (41)$$

VI. SIMULATION RESULT

MATLAB simulation shows that the performance of proposed ZCT-SLM based Alamouti STBC MIMO-OFDM system significantly improves the PAPR. To show the effect of our proposed ZCT-SLM based Alamouti STBC MIMO OFDM system we use two transmitting antenna M= 2 with BPSK modulation technique. We compared our result with ZCT-SLM based OFDM system for N = 128.

Fig. 9 shows the CCDF comparisons of PAPR of ZCT-SLM based OFDM system with ZCT-OFDM system, SLM-OFDM system and conventional OFDM system with and without adding cyclic prefix at clip rate of $10^{-3}$and the PAPR is 8.0 dB, 8.6dB, 9.0 dB, 11.0 dB and 11.0 dB.

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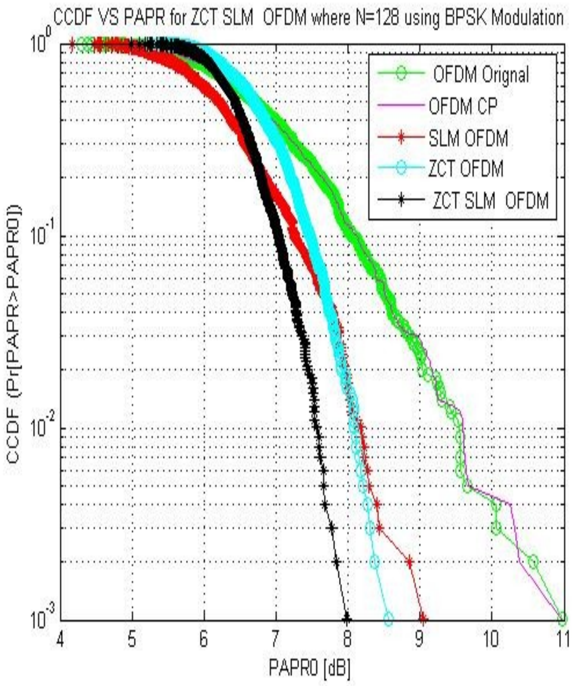

Fig. 9 CCDF Vs PAPR of ZCT-SLM based OFDM system with ZCT-OFDM system, SLM-OFDM system and conventional OFDM system with and without adding cyclic prefix

Fig. 10 shows the CCDF comparisons of PAPR of ZCT-SLM based Alamouti STBC MIMO-OFDM system with ZCT MIMO-OFDM system, SLM MIMO-OFDM system and conventional MIMO-OFDM system with and without adding cyclic prefix at clip rate of $10^{-3}$and the PAPR is 7.5 dB, 7.7 dB, 8.6 dB, 10.1 dB and 10.1 dB.

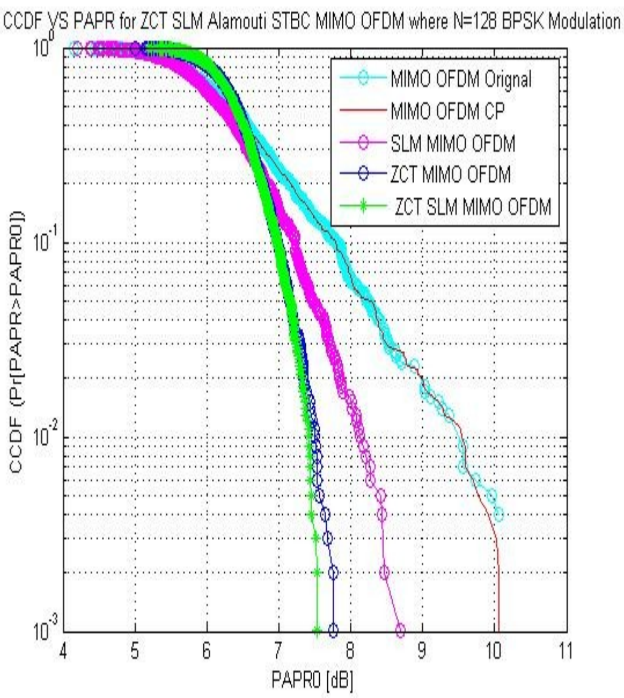

Fig. 10 CCDF Vs PAPR of ZCT-SLM based Alamouti STBC MIMO-OFDM system with ZCT MIMO-OFDM system, SLM MIMO OFDM system and conventional MIMO-OFDM system with and without adding cyclic prefix

TABLE I PAPR ANALYSIS *FOR N=128 USING BPSK MODULATION.*

SYSTEM	**PAPR in dB**
OFDM ORIGINAL	11.0
OFDM CP	11.0
SLM OFDM	9
ZCT OFDM	8.6
ZCT-SLM OFDM	8
MIMO OFDM ORIGINAL	10.1
MIMO OFDM CP	10.1
SLM MIMO OFDM	8.6
ZCT MIMO OFDM	7.7
ZCT-SLM MIM OOFDM	7.5

VII. CONCLUSIONS

In this paper, we present an analysis of the PAPR for the ZCT-SLM based MIMO-OFDM system using Alamouti STBC with ZCT-SLM based OFDM system .Simulation results have shown that the ZCT based STBC MIMO-OFDM system has much lower PAPR than the ZCT-SLM based OFDM system. Hence, we concluded that the ZCT based STBC MIMO-OFDM system is more favourable than the ZCT-SLM based OFDM system. This technique does not require any complex optimization; additionally it is efficient, signal independent, distortion less.

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