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PAPR Reduction of OFDM System Using PROPOSED PTS

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Abstract— ***Partial transmit sequence (PTS) is a promising technique for reducing the high peak-to-average power ratio (PAPR) in orthogonal frequency division multiplexing (OFDM) systems. In Conventional PTS, multiple candidate signals are generated and the optimal signal with the lowest PAPR is selected for transmission. One drawback of Conventional PTS is that parts of the candidate signals are strongly correlated so as to degrade the PAPR reduction performance. The other is the high complexity. In this paper, A new PTS is proposed to deal with these drawbacks of C-PTS. The candidates can be generated through cyclically left and right shifting each subblock sequence in time domain and combining them. Theoretical analysis and simulation results shows that the new scheme can achieve higher PAPR reduction.***

Index Terms— *OFDM, PAPR, PTS.*

I. INTRODUCTION

ORTHOGONAL frequency division multiplexing (OFDM) is an attractive technique for wireless high-rate data transmission due to the minimizing effect over frequency-selective fading channels. OFDM has been chosen for European Digital Audio Broadcasting (DAB), Digital Video Broadcasting (DVB), WLAN standards (802.11), WiMax (802.16) and is being considered for the long term evolution of 3GPP. However, OFDM has some drawbacks in the transmission system. One of the major problems of the OFDM system is that it has higher peak to-average-power ratio (PAPR) than single carrier signal because OFDM signal is the sum of many narrowband signals in the time domain. The high PAPR can cause inter modulation and out-of-band radiation due to power amplifier nonlinearity. In order to combat this problem, the transmission amplifier must operate within its linear region to prevent spectral distortion and the degradation of the bit error rate (BER). High linearity normally implies low efficiency and large power dissipation, which is prohibitive for use in portable wireless applications. Therefore, it is highly desirable to reduce the PAPR of an OFDM signal.

Many methods have been proposed including clipping of the OFDM signal, coding techniques, active constellation extension (ACE), companding transform, tone reservation (TR), tone injection (TI), partial transmit sequence (PTS), selective mapping (SLM) and various combinations of the above. Among them, SLM and PTS are two promising techniques because they are simple to implement, no distortion in the transmitted signal and can significantly improve the statistics of the PAPR. However, the conventional SLM and PTS suffer from higher computational complexity due to several N–dimension inverse fast Fourier transform (IFFT) operations, where N is the number of subcarriers. In order to recover the original OFDM signal successfully, the transmitter has to send the selected signal index, called side information, to the receiver using extra subcarrier. It will degrade the OFDM system's spectru efficiency. The BER performance of the OFDM systems can possibly be degraded significantly since any error in the detection of side information can damage the entire data block.

The rest of the this paper is organized as follows. In Section II, the PAPR Problem of OFDM system is formulated and the principle of Conventional –PTS is explained.The proposed PTS is presented in Section III. In Section IV Simulation Result are discussed, Finally conclusion are drawn in Section V.

II. OFDM SYSTEM USING C- PTS TO REDUCE PAPR

In OFDM system, a block of symbols is formed with each symbol modulating by one set of subcarrier. Then, an OFDM signal is obtained by summing up all the modulated independent subcarriers, where is the number of subcarriers. The subcarriers are chosen to be orthogonal such that the adjacent subcarrier separation where is the OFDM signal duration. The mathematical representation of the OFDM signal can be written as

$$x(t) = \frac{1}{\sqrt{N}} \sum_{t=0}^{N-1} X(l) e^{j2\pi l \Delta f t}; 0 \le t \le T \qquad (1)$$

The subcarrier vector is formed according to a certain modulation scheme such as quadrature amplitude modulation (QAM). Thus, is a vector of constellation symbols from a constellation ξ.

The PAPR of OFDM signal in one symbol period is defined as the ratio between the maximum instantaneous power and its average power, which can be written as

$$PAPR = 10\log 10 \frac{\max_{o \le t \le T} \left| x(t)^2 \right|}{P_{av}} \qquad (2)$$

Where, P_{av} is the average power of and x(t) it can be computed in the frequency domain because IFFT is a (scaled) unitary transformation.

The transmitted discrete signal x[n] is usually generated by sampling the continuous time signal x(t) Hence, x[n] is usually oversampled by a factor L to have a better estimation of the PAPR value of continuous time signal x(t). The oversampling by the factor L can be realized by inserting (L-1)N zeros in the middle of the N–point frequency domain signal X and passing the new LN -point data sequence through the LN-point IFFT unit. Therefore, the oversampled IFFT output can be expressed as

$$x(n) = \frac{1}{\sqrt{LN}} \sum_{t=0}^{LN-1} X(l) e^{j2\pi \ln/N}; 0 \le n \le LN-1 \qquad (3)$$

where

$$\bar{X} = \left[X(0),....X(N/2-1), \underbrace{0,....0}_{(L-1)N}, X(N/2),...,X(N-1) \right]^T$$

It is shown L = 4 is sufficient to capture the peak information of x(t). The Block Diagram of OFDM System Using Conventional PTS (C-PTS) is shown in Figure 1. In OFDM system with PTS approach to reduce the PAPR, the input data block in is divided by means of a certain partitioning scheme into disjoint sub-blocks, which are represented by the vectors $\{X_v, v = 1,2,.............V\}$.

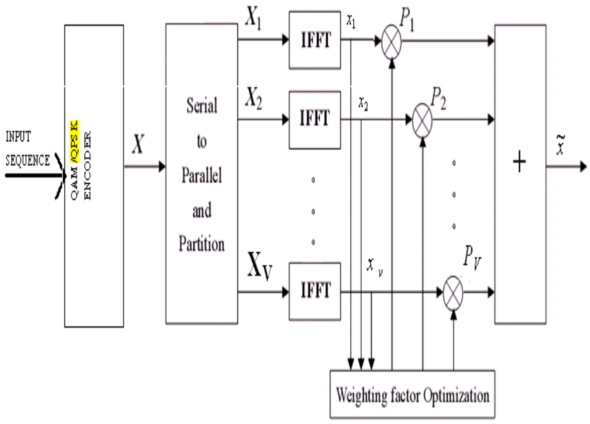

Figure 1. BLOCK DIAGRAM of CONVENTIONAL PTS

Therefore, we can get

$$X = \sum_{v=1}^{V} X_v \qquad (4)$$

Where, all the subcarrier positions which are presented in another block must be zero so that the sum of all the sub-blocks constitutes the original signal. Then, the sub-blocks are transformed into time-domain partial transmit sequence, which can be represented as

$$x_v = IFFT_{LNXN} \{Xv\} \qquad (5)$$

After that, these partial sequences are independently rotated by the phase factors P = [P1,………P_V] and combined together to create a set of candidates

$$\tilde{x} = \sum_{v=1}^{V} Pv x_v = \sum_{v=1}^{V} IFFT\{Pv \Theta Xv\} \qquad (6)$$

Suppose that alphabet **R** denotes the set of the value of ***Pv***, *v* = 1,2,…..V, and K is the number in set R . Usually, the choice of R from $\{\pm 1\}$ for K= 2 or $\{\pm 1, \pm j\}$ for K =4 is interesting since no actual multiplication is performed to rotate the phase. Finally, the candidate with the lowest PAPR is chosen by exhaustive search of the candidates for transmission.

III. PROPOSED PTS SCHEME TO REDUCE PAPR

The diagram of Proposed PTS Scheme for Lower the PAPR value of the OFDM System is shown in figure 2. The aim of the proposed PTS scheme is to lower the PAPR Value of the transmitter and detector while the receiver can recover the original signal without side information. the conventionalinterleaved partitioning PTS scheme are not fully independent, which leads to performance inferior to Proposed PTS scheme. After enhancing the independence among the candidates,the PAPR performance of the amended interleaved partitioning PTS scheme can be improved. After obtaining the time domain signal $x_v (v = 1,........, V)$ in eq. (5), instead of applying different phase vectors **P** on x_v as the C-PTS scheme, the proposed scheme generates new candidates by cyclically shifting with up (or to the left) and down (or to the right) signals x_v and combining them together.

$$\tilde{x} = odd\sum_{v=1}^{V}\tilde{x}_v(+k) + even\sum_{v=1}^{V}\tilde{x}_v(-k) \quad (7)$$

Where k = 1,2,……………,2^V .

V is the sub-block of OFDM signal 4,8, 16.

$\pm k$ is the shifting number for left or right.

$$\tilde{x}_v(\pm k) = circshift(\tilde{x}_v, \pm k) \quad (8)$$

For positive k right shift

$$\tilde{x}_v(+k) = [x_v(k),.........., x_v(LN-1), x_v(0), x_v(1),......., x_v(k-1)] \quad (9)$$

For negative k left shift

$$\tilde{x}_v(-k) = [x_v(k-1),.........., x_v(1), x_v(0), x_v(LN-1),..............., x_v(k)] \quad (10)$$

Here $\tilde{x}_v(\pm k) = circshift(x_v, \pm k)$ circularly shifts the values in the OFDM sub block $'x_v'$ by shift size 'k' elements. Shift size 'k' is a vector of integer scalars where the i^th^ element specifies the shift amount for the i^th^ dimension of OFDM sub block $'x_v'$. If an element in shiftsize 'k' is positive, the values of OFDM sub block $'x_v'$ are shifted down (or to the right). If it is negative, the values of OFDM sub block $'x_v'$ are shifted up (or to theleft). The candidate with the lowest PAPR is chosen for transmission. The following are the advantages of the shifting technique in the proposed PTS scheme. First, no multiplication is required. Second, by utilizing the

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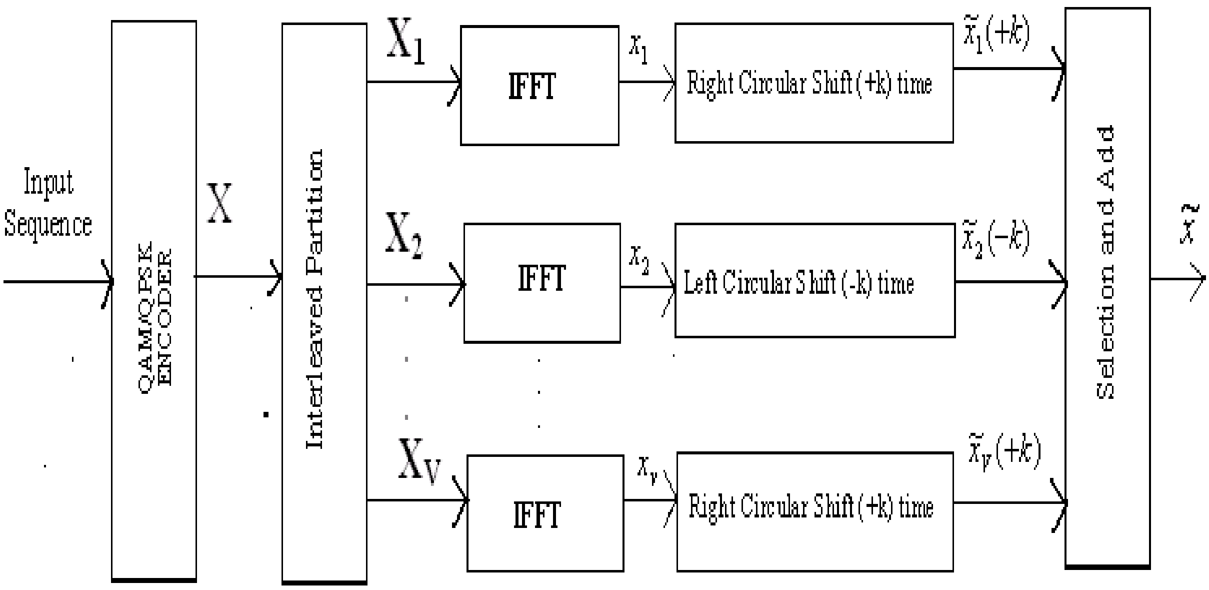

Figure 2. BLOCK DIAGRAM of OFDM SYSTEM USING PROPOSED PTS

property of IFFT for different shift number , cyclically shifted signal will have distinct phase constellation in some of frequency domain signals. Thus, in the receiver, the detector can determine which shift number operated on the sub-block according to the phase constellation of the received side

IV. SIMULATION RESULTS

To illustrate the effectiveness of the proposed scheme, we consider simulation results to evaluate the performance in terms of PAPR reduction. The results of the simulation are based on the transmission of randomly generated **3x10⁵** OFDM symbols with the carriers N= 64, 128 and 256 under the condition of an oversampling factor L=4 and 16-QAM/QPSK modulation techniques are examined here. The complementary cumulative density function (CCDF) of the PAPR is used to measure the performance. The CCDF of the PAPR is defined as

$$CCDF\ (PAPR\ (\ x[n]\ )) = P_r\ (\ PAPR\ (\ x\ [n] > PAPR_0\ )$$

where $PAPR_0$ is a certain threshold value that is usually given in decibels relative to the root mean square (RMS) value. The CCDFs of the proposed PTS scheme with sub-block 4 , 16-QAM/QPSK modulation and phase set K = 4 are shown from Figure 3 to Figure 5 .
The CCDFs of the original OFDM system without PAPR reduction and Conventional PTS for each value of N for comparison purpose are also plotted. It is observed that the performance of proposed PTS scheme in terms of PAPR reduction is better than the Conventional PTS. It also improves as the no of carriers N decreases. The PAPR0/db of the proposed PTS scheme with QPSK are found to be 5.5 dB, 6.0 dB and 6.2 dB for N= 64, N = 128, N = 256 with V=4, K = 4, L=4 when Pr = 10^{-4} . The PAPR0/db of the proposed PTS scheme with 16-QAM are found to be 5.5 dB, 5.8 dB and 6.25 dB for N= 64, N = 128, N = 256 with V=4, K = 4, L=4 when Pr = 10^{-4} . The Comparison table of the PAPR0/db , Pr values for Proposed PTS, C-PTS and original OFDM symbole for N = 64, N = 128 and N = 256 for V=4, K=4 are given in table 1 to table 3.

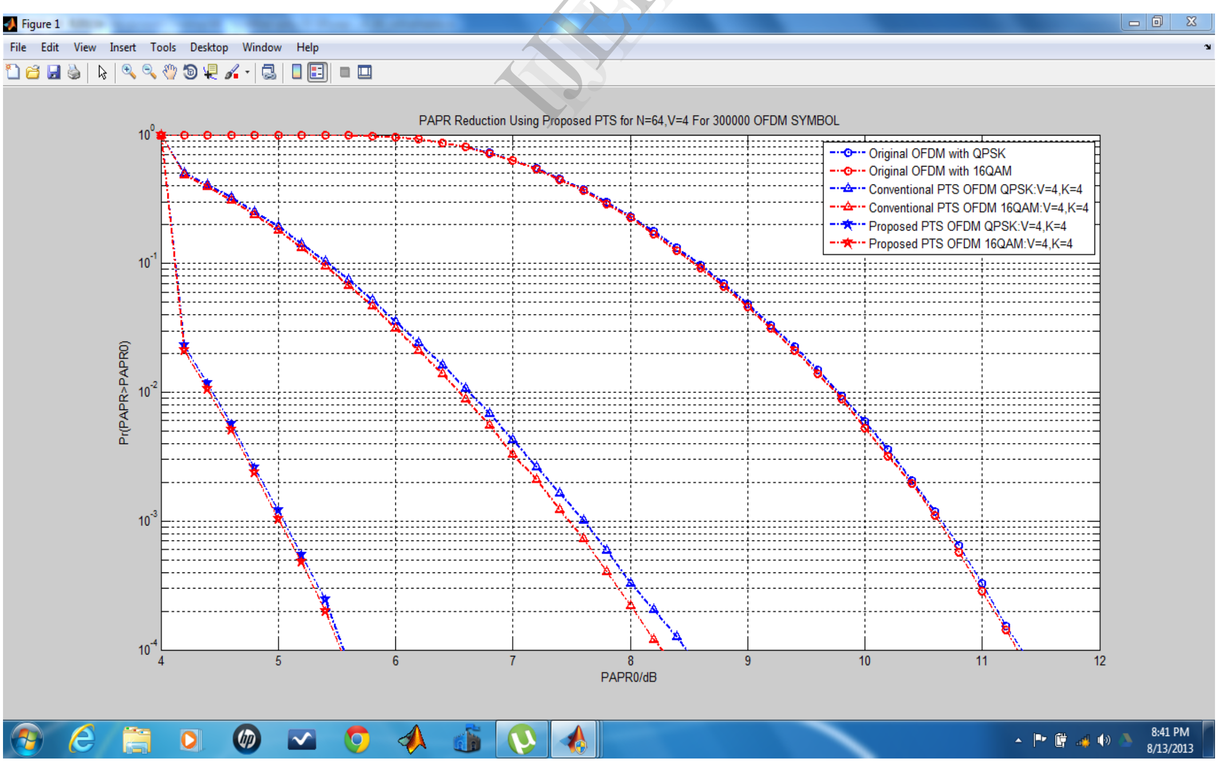

Figure 3. PAPR performance of the proposed PTS, C-PTS and original OFDM symbole for N= 64, V=4, K=4.

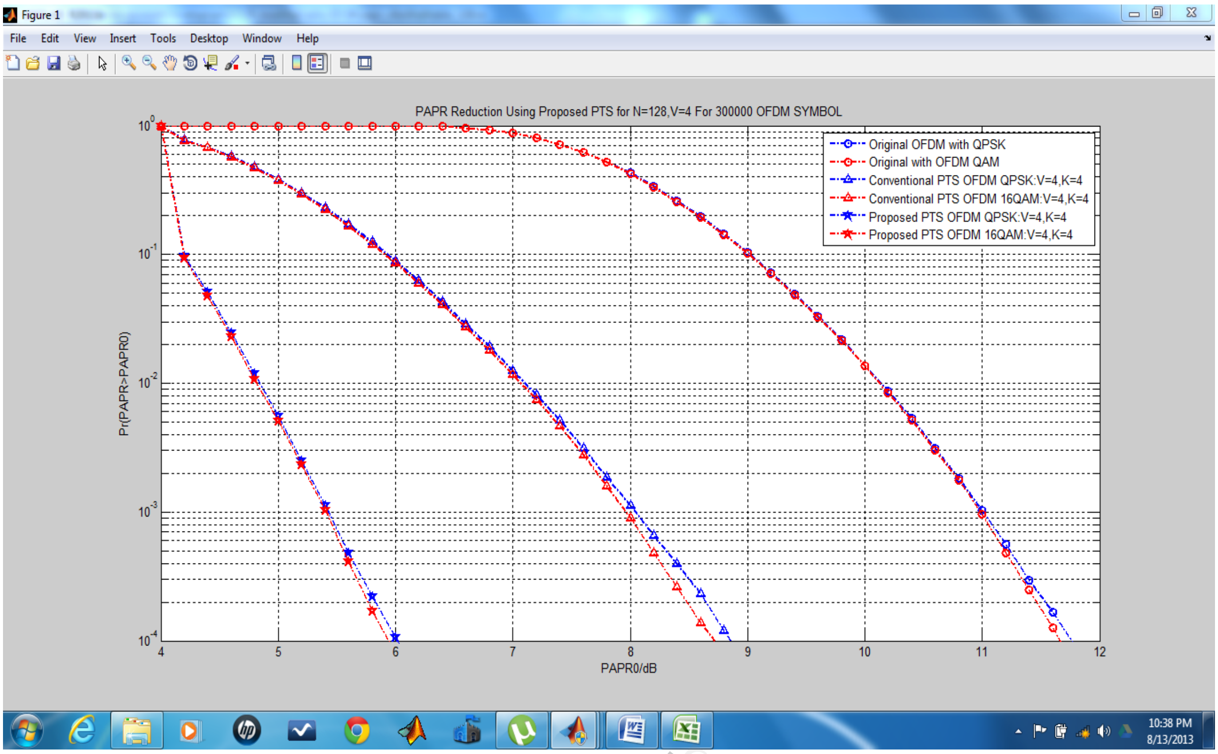

Figure 4. PAPR performance of the proposed PTS, C-PTS and original OFDM symbole for N= 128, V=4, K=4.

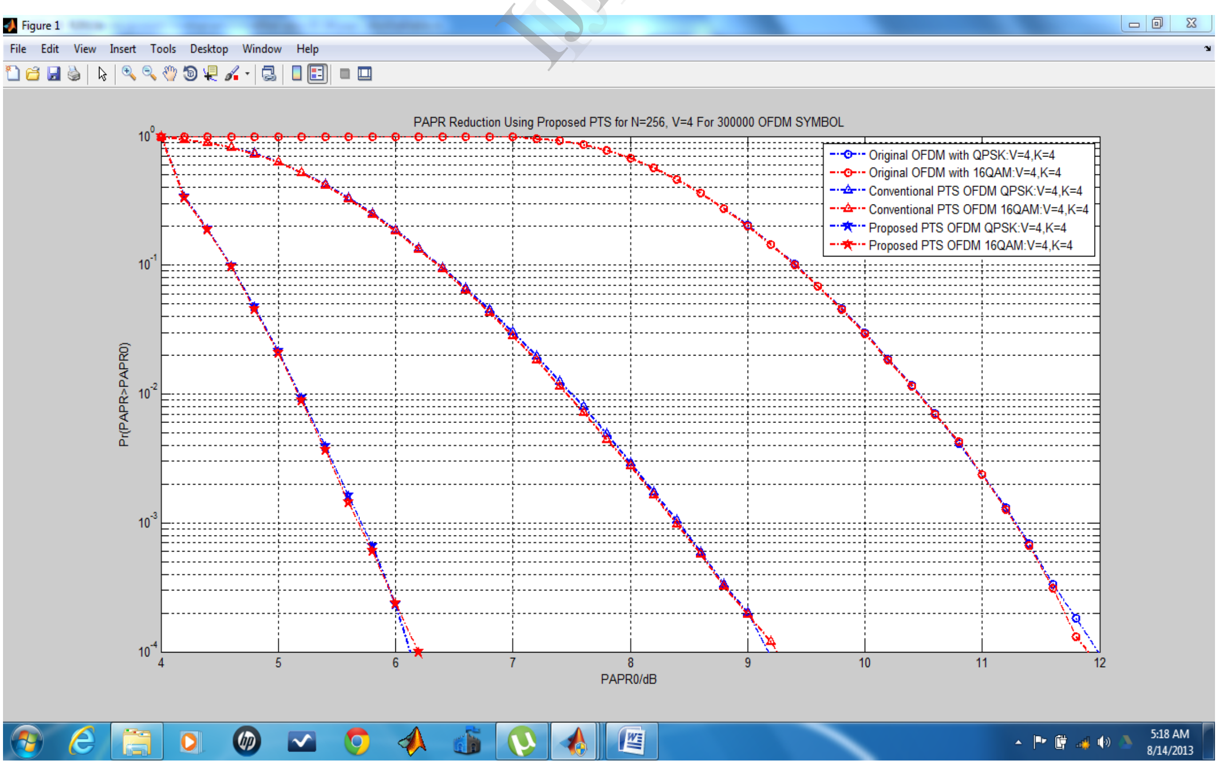

Figure 5. PAPR performance of the proposed PTS, C-PTS and original OFDM symbole for N= 256, V=4, K=4**.**

Table 1: Comparison table of Pr values for Proposed PTS, C-PTS and original OFDM symbole for N= 64, V=4, K=4.

	QPSK(N=64, V=4, K=4)			**16-QAM (N=64, V=4, K=4)**		
	Original OFDM	**C_PTS**	**Proposed PTS**	**Original OFDM**	**C- PTS**	**Proposed PTS**
PAPR0/db	Pr(PAPR>PAPR0)	Pr(PAPR>PAPR0)	Pr(PAPR>PAPR0)	Pr(PAPR>PAPR0)	Pr(PAPR>PAPR0)	Pr(PAPR>PAPR0)
5	0.9997	0.1928	0.0012	0.9997	0.1811	0.001
5.2	0.9989	0.1433	5.43E04	0.9988	0.1334	4.80E04
5.4	0.9968	0.1042	2.43E04	0.9964	0.0961	2.00E04
5.6	0.9907	0.0744	8.00E05	0.9902	0.0675	7.00E05
5.8	0.978	0.0518	3.00E05	0.9773	0.0468	2.67E05
6	0.9553	0.0357	1.33E05	0.9538	0.0315	1.67E05
6.2	0.9196	0.0242	6.67E06	0.9177	0.021	0
6.4	0.8689	0.0163	3.33E06	0.8658	0.0139	0
6.6	0.8025	0.0107	3.33E06	0.7987	0.0089	0
6.8	0.7229	0.0068	0	0.7185	0.0055	0
7	0.6362	0.0042	0	0.6305	0.0033	0
7.2	0.547	0.0026	0	0.5385	0.0021	0
7.4	0.4575	0.0016	0	0.4493	0.0012	0
7.6	0.3732	0.001	0	0.3663	7.23E04	0
7.8	0.2981	5.90E04	0	0.2906	4.03E04	0
8	0.2317	3.27E04	0	0.2253	2.20E04	0
8.2	0.1766	2.07E04	0	0.1702	1.20E04	0
8.4	0.1317	1.27E04	0	0.1268	7.33E05	0
8.6	0.0967	7.00E05	0	0.0926	4.67E05	0
8.8	0.0696	3.00E05	0	0.066	2.00E05	0
9	0.0484	6.67E06	0	0.0462	1.33E05	0
9.2	0.0333	3.33E06	0	0.0315	3.33E06	0
9.4	0.0225	0	0	0.0211	0	0
9.6	0.0148	0	0	0.0138	0	0
9.8	0.0094	0	0	0.0088	0	0
10	0.0059	0	0	0.0053	0	0
10.2	0.0036	0	0	0.0032	0	0
10.4	0.0021	0	0	0.0019	0	0
10.6	0.0012	0	0	0.0011	0	0
10.8	6.47E04	0	0	5.70E04	0	0
11	3.30E04	0	0	2.87E04	0	0
11.2	1.53E04	0	0	1.43E04	0	0
11.4	8.33E05	0	0	7.00E05	0	0
11.6	3.67E05	0	0	2.67E05	0	0
11.8	1.67E05	0	0	6.67E06	0	0
12	1.33E05	0	0	0	0	0

Table 2: Comparison table of Pr values for Proposed PTS, C-PTS and original OFDM symbole for N= 128, V=4, K=4.

	QPSK(N=128, V=4, K=4)			16-QAM (N=128, V=4, K=4)		
	Original OFDM	C_PTS	Proposed PTS	Original OFDM	C- PTS	Proposed PTS
PAPR0/db	Pr(PAPR>PAPR0)	Pr(PAPR>PAPR0)	Pr(PAPR>PAPR0)	Pr(PAPR>PAPR0)	Pr(PAPR>PAPR0)	Pr(PAPR>PAPR0)
5	1	0.3852	0.0055	1	0.3777	0.005
5.2	1	0.3007	0.0025	1	0.2938	0.0023
5.4	1	0.2296	0.0011	1	0.2229	0.001
5.6	0.9999	0.1713	4.80E04	0.9999	0.1652	4.10E04
5.8	0.9997	0.1252	2.20E04	0.9996	0.1191	1.70E04
6	0.9983	0.089	1.07E04	0.9982	0.0853	8.00E05
6.2	0.9944	0.0624	3.67E05	0.994	0.0595	1.67E05
6.4	0.9848	0.0429	1.33E05	0.9839	0.0408	6.67E06
6.6	0.9642	0.0288	0	0.964	0.0276	0
6.8	0.9297	0.0193	0	0.9281	0.018	0
7	0.8772	0.0126	0	0.8736	0.0117	0
7.2	0.8056	0.0082	0	0.8014	0.0074	0
7.4	0.7189	0.0051	0	0.7147	0.0047	0
7.6	0.623	0.0031	0	0.6174	0.0027	0
7.8	0.5235	0.0019	0	0.5184	0.0016	0
8	0.4276	0.0011	0	0.4224	8.90E04	0
8.2	0.3391	6.53E04	0	0.3352	4.80E04	0
8.4	0.2618	4.00E04	0	0.2584	2.60E04	0
8.6	0.1971	2.30E04	0	0.1935	1.37E04	0
8.8	0.1444	1.20E04	0	0.142	8.33E05	0
9	0.1036	6.67E05	0	0.1016	3.67E05	0
9.2	0.0727	2.67E05	0	0.0712	1.67E05	0
9.4	0.0497	1.67E05	0	0.0486	1.33E05	0
9.6	0.0333	1.33E05	0	0.0325	1.00E05	0
9.8	0.0218	3.33E06	0	0.0213	3.33E06	0
10	0.0136	3.33E06	0	0.0137	0	0
10.2	0.0087	0	0	0.0084	0	0
10.4	0.0054	0	0	0.0052	0	0
10.6	0.0032	0	0	0.003	0	0
10.8	0.0018	0	0	0.0018	0	0
11	0.001	0	0	9.70E04	0	0
11.2	5.60E04	0	0	4.77E04	0	0
11.4	2.97E04	0	0	2.47E04	0	0
11.6	1.67E04	0	0	1.27E04	0	0
11.8	9.00E05	0	0	6.33E05	0	0
12	5.67E05	0	0	4.67E05	0	0

Table 3: Comparison table of Pr values for Proposed PTS, C-PTS and original OFDM symbole for N= 256, V=4, K=4.

	QPSK(N=256, V=4, K=4)			16-QAM (N=256, V=4, K=4)		
	Original OFDM	C_PTS	Proposed PTS	Original OFDM	C- PTS	Proposed PTS
PAPR0/db	Pr(PAPR>PAPR0)	Pr(PAPR>PAPR0)	Pr(PAPR>PAPR0)	Pr(PAPR>PAPR0)	Pr(PAPR>PAPR0)	Pr(PAPR>PAPR0)
5	1	0.6306	0.0216	1	0.6265	0.0207
5.2	1	0.5254	0.0093	1	0.5214	0.0088
5.4	1	0.4233	0.0039	1	0.4193	0.0036
5.6	1	0.3318	0.0016	1	0.328	0.0014
5.8	1	0.2522	6.57E04	1	0.2484	6.03E04
6	1	0.1872	2.30E04	1	0.1842	2.37E04
6.2	1	0.1359	6.33E05	1	0.133	1.00E04
6.4	0.9998	0.0954	2.33E05	0.9998	0.0937	4.67E05
6.6	0.9988	0.066	1.33E05	0.9989	0.064	0
6.8	0.9954	0.045	6.67E06	0.9953	0.0429	0
7	0.986	0.0302	0	0.9857	0.0282	0
7.2	0.9647	0.0195	0	0.964	0.0183	0
7.4	0.9256	0.0125	0	0.9243	0.0114	0
7.6	0.8648	0.008	0	0.8624	0.0072	0
7.8	0.7817	0.0049	0	0.7784	0.0044	0
8	0.6815	0.0029	0	0.6777	0.0028	0
8.2	0.5726	0.0017	0	0.5691	0.0016	0
8.4	0.4642	0.001	0	0.4608	9.80E04	0
8.6	0.3637	5.90E04	0	0.361	5.70E04	0
8.8	0.2764	3.37E04	0	0.2727	3.23E04	0
9	0.2033	2.03E04	0	0.2013	1.97E04	0
9.2	0.1456	9.33E05	0	0.1439	1.20E04	0
9.4	0.1015	6.00E05	0	0.1004	6.00E05	0
9.6	0.0692	2.00E05	0	0.068	2.67E05	0
9.8	0.0459	1.00E05	0	0.0451	1.33E05	0
10	0.0297	3.33E06	0	0.0294	1.00E05	0
10.2	0.0187	3.33E06	0	0.0185	1.00E05	0
10.4	0.0117	0	0	0.0115	0	0
10.6	0.0071	0	0	0.007	0	0
10.8	0.0041	0	0	0.0043	0	0
11	0.0024	0	0	0.0024	0	0
11.2	0.0013	0	0	0.0013	0	0
11.4	6.90E04	0	0	6.67E04	0	0
11.6	3.33E04	0	0	3.13E04	0	0
11.8	1.83E04	0	0	1.30E04	0	0
12	9.67E05	0	0	8.00E05	0	0

V. CONCLUSION

An interleaved partitioning PTS scheme making use of the left and right cyclically shifting sub-block sequences and linear property of IFFT is presented in this paper. No multiplication is performed by the cyclically shifting. By utilizing cyclically shifting of the sub-block sequence, a set of candidates with different phase constellation will be generated according to the different shifting number of the subblock. In such case the detector can distinguish which candidates had been transmitted without any side information. Cyclically shifted sub-block sequences also increase the independence and the total number of candidates compared with the conventional PTS scheme. The PTS technique requires V IFFT operations for each data block. The PAPR performance of the PTS technique is affected by the number of subblocks, V, and the number of the allowed phase factors w. The C- PTS suffers from the complexity of searching for the optimum set of phase vector, especially when the number of subblock increases. Figure 3 to Figure 5 shows the CCDF of PAPR for a 16-QAM/QPSK OFDM system using Proposed PTS, Conventional PTS and Original OFDM Signal with Sub-block V =4 . It is seen that the PAPR performance improves as the number of carriers decreases from N= 256 to N=64.

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