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PAPR Reduction in Multi-Carrier Transmission Based on Partial Transmit Sequence

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Abstract:- In this paper, we present the peak-to-average power (PAPR) reduction in multicarrier transmission based on partial transmit Sequence (PTS). We are using the signal scrambling techniques for PAPR reduction. Partial transmit sequence work with side information which minimized the effective throughput since they commence redundancy. In the proposed scheme, 2^n -point inverse fast Fourier transform (IFFT) is divided into two parts. An input symbol sequence is partially transformed using the first l stages of IFFT into an intermediate signal sequence and the intermediate signal sequence is partitioned into a number of intermediate signal subsequences. Then, the remaining l-n stages of IFFT are applied to each of the intermediate signal subsequences and the resulting signal subsequences are summed after being multiplied by each member of a set of W rotating vectors to yield W distinct OFDM signal sequences. The one with the lowest peak to average power ratio (PAPR) among these OFDM signal sequences is selected for transmission. This technique is using the fast Fourier transform (FFT) to transform the signal to frequency domain which is more efficient compared to that of other PAPR Reduction Techniques. Simulation result show that as the number of sub blocks increases, the performance of the channel goes on improving. The simulation results reveal that the PTS technique outperforms the other signal scrambling techniques.

Index terms:- **fast Fourier transform (FFT), peak-to-average power (PAPR), inverse fast Fourier transform (IFFT), partial transmit Sequence (PTS).**

I. INTRODUCTION

Multi-carrier transmission [1][2] is a modulation scheme that splits the available bandwidth into many subcarriers through the use of a discrete Fourier transform. Multiplexing a serial data symbol stream into a large number of orthogonal sub channel makes the multi-carrier modulation signals spectral bandwidth efficient. It has been shown that the performance of OFDM system [1] over frequency selective fading channels is better than that of the single carrier modulation system. One of the major drawbacks of OFDM system is that the OFDM signal can have high peak to average power ratio (PAPR). The high PAPR brings on the OFDM signal distortion in the nonlinear region and the signal distortion induces the degradation of bit error rate (BER).

Signal scrambling techniques [3] work with side information which minimized the effective throughput since they commence redundancy. Signal distortion techniques introduce band interference and system complexity also. Signal distortion techniques minimize high peak dramatically by distorting signal before amplification.

Many methods have been proposed to resolve the high-PAPR problem of OFDM signals [2], including clipping [3], tone reservation [4], tone injection [5], coding [6], companding transforms [7], [8], selected mapping (SLM) [9], [10], and partial transmit sequences (PTS)[11]-[16] . In block coding the encoding of an input data into a codeword with low PAPR is another well known technique to reduce PAPR, but it incurs the rate decrease. In the SLM scheme, an input symbol sequence is multiplied by each of the phase sequences to generate alternative input symbol sequences. In the PTS scheme, the input symbol sequence is partitioned into a number of disjoint symbol subsequences. IFFT is then applied to each symbol subsequence and the resulting signal subsequences are summed after being multiplied by a set of distinct rotating vectors.

In this paper, we present the peak-to-average power (PAPR) reduction in multicarrier transmission based on partial transmit Sequence (PTS). In the proposed scheme, 2^n -point inverse fast Fourier transform (IFFT) is divided into two parts. An input symbol sequence is partially transformed using the first l stages of IFFT into an intermediate signal sequence and the intermediate signal sequence is partitioned into a number of intermediate signal subsequences. Then, the remaining l-n stages of IFFT are applied to each of the intermediate signal subsequences and the resulting signal subsequences are summed after being multiplied by each member of a set of W rotating vectors to yield W distinct OFDM signal sequences. The one with the lowest peak to average power ratio (PAPR) among these OFDM signal sequences is selected for transmission.

The rest of the paper is organized as follows: In Section II, The OFDM system is explained with the help of detail description of each block of the OFDM system. In section III, different mathematical formulation of the peak to average power ratio is introduced. Section IV presents partial transmits sequence. Section V, simulation results will be explained with comparative analysis of complementary cumulative distribution function with PAPR. Section VI, conclusions will be made.

II. OFDM

In an OFDM system, the total signal frequency band is divided into N non-overlapping frequency sub channels. Each sub channel is modulated with a separate symbol, and then the N sub channels are frequency multiplexed. It seems good to avoid spectral overlap of channels to eliminate inter-channel interference. However, this leads to inefficient use of the available spectrum. To cope with the inefficiency, the ideas proposed in the mid-1960s were to use parallel data and FDM with overlapping sub channels, in which each, carrying a signalling rate b, is spaced b apart in frequency to avoid the use of high-speed equalization and to combat impulsive noise and multipath distortion, as well as to use the available bandwidth fully. By using the overlapping multicarrier modulation technique, almost 50% of bandwidth can be saved.

Basic Principal of OFDM system [3] is to divide high data rate transmission into lower data rate and that are transmitted simultaneously over number of subcarriers. Each of these signal are individually modulated and transmitted over the channel. And at the Receiver and signal will be demodulated and recombine to recover the Original Signal. As shown in figure given below each subcarrier arranged orthogonally in spectrum. Periodic signal are orthogonal when integral of their product is zero. Fig. 1 shows the block diagram of the OFDM system.

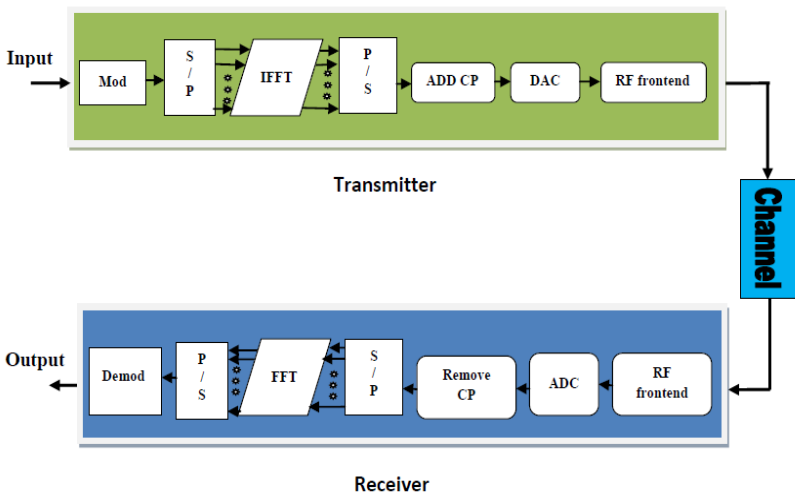

Fig. 1 Block Diagram of OFDM

Modulation: Modulation is the technique by which the signal wave is transformed in order to send it over the communication channel in order to minimize the effect of noise. This is done in order to ensure that the received data can be demodulated to give back the original data. In an OFDM system, the high data rate information is divided into small packets of data which are placed orthogonal to each other. This is achieved by modulating the data by a desirable modulation technique (QPSK). After this, IFFT is performed on the modulated signal which

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is further processed by passing through a parallel to serial converter. In order to avoid ISI we provide a cyclic prefix to the signal.

Communication Channel: This is the channel through which the data is transferred. Presence of noise in this medium affects the signal and causes distortion in its data content.

Demodulation: Demodulation is the technique by which the original data (or a part of it) is recovered from the modulated signal which is received at the receiver end. In this case, the received data is first made to pass through a low pass filter and the cyclic prefix is removed. FFT of the signal is done after it is made to pass through a serial to parallel converter. A demodulator is used, to get back the original signal. The bit error rate and the signal to noise ratio is calculated by taking into consideration the unmodulated signal data and the data at the receiving end.

III. PEAK-TO-AVERAGE RATIO

Peak-to-Average ratio describes the envelope fluctuation. The system should operate in the linear region. Large peaks cause saturation in the power amplifiers and amplifier saturation results in non-linear distortion. One particular problem with multicarrier is the large envelope fluctuation.
The complex envelop of the OFDM signal, over T second interval is given by:

$$x_n = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k . e^{j2\pi \frac{n}{N} k} \quad , n = 0,1,2, \ldots N-1 \tag{4}$$

X_k where is the carrier amplitude
The envelope dynamic of signal x(t) can be objectively measured using the parameter called Peak to Average Power Ratio (PAPR) defined as:

$$PAPR = \frac{max|x_n|^2}{E[|x_n|^2]} \tag{3}$$

Statistically it is possible to characterize the PAPR distribution using its cumulative distribution function (CDF) or complementary cumulative distribution function (CCDF). For the case of OFDM, the following expression for the PAPR CCDF holds as

$$P(PAPR > PAPR_0) = 1 - (1 - e^{-PAPR_0})^N \tag{4}$$

When signals with high PAPR are passed through the transmitter signal amplifier, they may suffer significant nonlinear distortion, which is undesirable. PAPR problems are solved using either a linear amplifier or back off the operating point of a nonlinear amplifier.

IV. PARTIAL TRANSMIT SEQUENCE (PTS)

PTS generates a signal with a low PAPR through the addition of appropriately phase rotated signal parts. The original signal is given

$$x_m = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_m . e^{j2\pi nk/N} \qquad \text{where } 0 \le n \le N-1 \tag{5}$$

In PTS approach, the input data block is partitioned into disjoint sub-blocks. The sub-carriers in each sub-block are weighted by phase rotations. The phase rotations are selected such that the PAPR is minimized. At the receiver, the original data are recovered by applying inverse phase rotations. In the PTS technique, an input data block of K symbols is partitioned into disjoint sub-blocks. The subcarriers in each sub-block are weighted by a phase factor for that sub-block. The phase factors are selected such that the PAPR of the combined signal is

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minimized. In order to implement this idea, the input data block of K symbols is partitioned into M pair wise disjoint blocks X_k, k = 1, ..., M.

Mainly, the total number of subcarriers included in any one of these sub-blocks X_k is arbitrary, but sub-blocks of equal size have been found to be an appropriate choice. All sub carrier positions in X_k, which are already represented in another sub-block, are initialized to zero, so that $X = \sum_{k=1}^{M} X_k$.

Each sub-block is weighted by a set of rotation factors $b_k(u)$ where u = 1…..U , so that a modified sub carrier vector $\hat{X} = \sum_{k=1}^{M} X_k b_k(u)$ is obtained, which represents the same information as X, if the set $b_k(u)$ is known for each u and k. The phase factors are selected such that the PAR of the combined signal is minimized.

The optimization is achieved by searching thoroughly for the best phase factor. Theoretically, **b**= $[b_1, b_2,...,b_M]$ is a set of discrete values, and numerous computation will be required for the system when this phase collection is very large. For example, if ϕM contains W possible values, theoretically, **b** will have W^M different combinations, therefore, a total of $M.W^M$ IFFTs will be introduced. By increasing the M, *W*, the computational cost of PTS algorithm will increase exponentially.

For instance, define phase factor b_M contains only four possible values, that means $b_M \epsilon \{\pm 1, \pm j\}$, then for each OFDM symbol, $2.M - 1$bits are transmitted as side information.

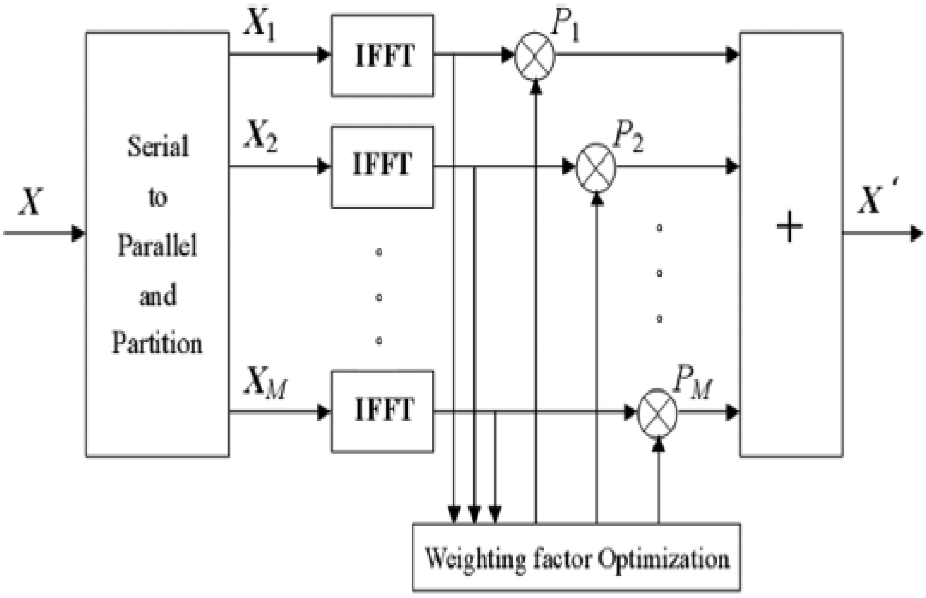

Fig. 2 Partial Transmit Sequence

V. SIMULATION RESULTS

To illustrate the effectiveness of the PTS scheme, we consider several simulation results to evaluate the performance in terms of PAPR reduction and bit error rate (BER) at the detector output. Simulation has been done in MATLAB and following parameters have been considered for simulation as: Number of subcarriers (N)= 256, Number of sub blocks (M)=2,4,8,16,32,64, Oversampling factor(L)=6, Modulation Scheme is 64-QAM. Fig. 3 shows the comparison CCDF of PAPR using Partial Transmit Sequence (PTS) technique with M=2, 4 of sub blocks and Number of subcarriers N=256. Fig. 4 shows the comparison CCDF of PAPR using Partial Transmit Sequence (PTS) technique with M=2, 4, 8 of sub blocks and Number of subcarriers N=256.

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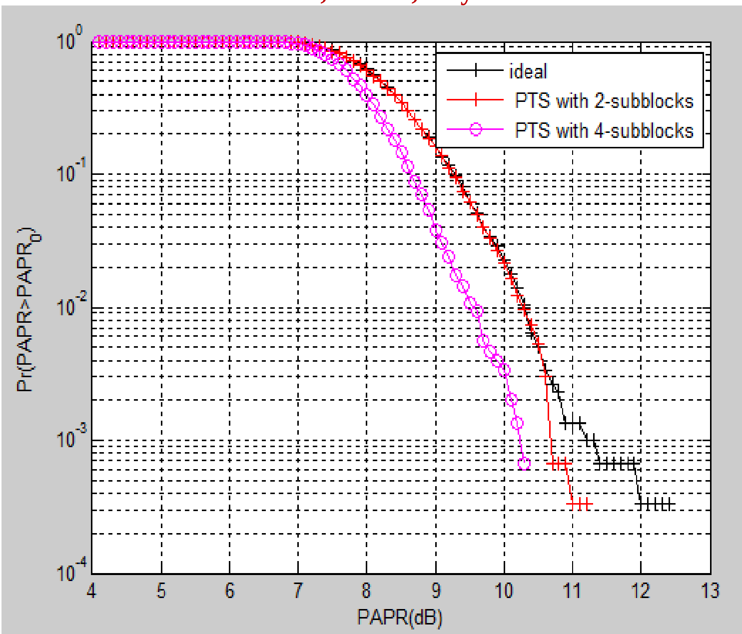

Fig. 3 comparison CCDF of PAPR using Partial Transmit Sequence (PTS) technique with M=2, 4 of sub blocks

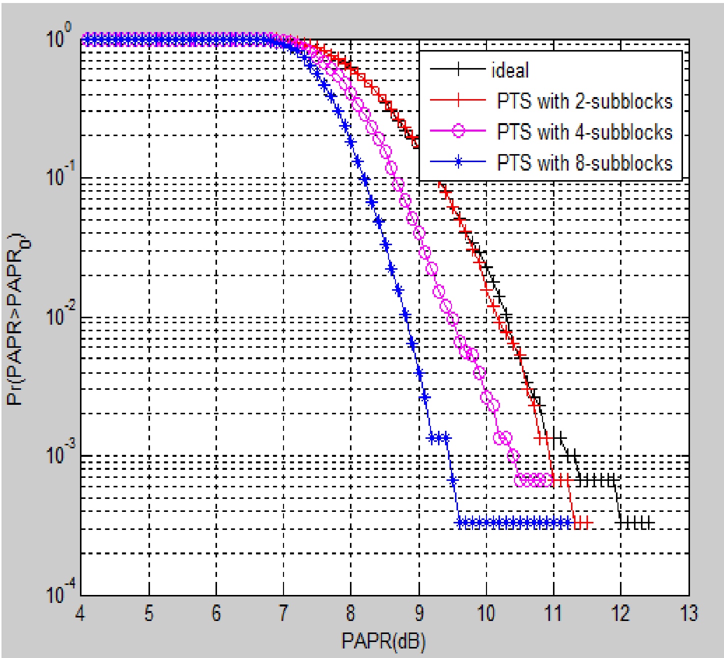

Fig. 4 comparison CCDF of PAPR using Partial Transmit Sequence (PTS) technique with M=2, 4,8 of sub blocks

Fig. 5 shows the comparison CCDF of PAPR using Partial Transmit Sequence (PTS) technique with M=2, 4,8,16 of sub blocks and Number of subcarriers N=256. Fig. 6 shows the comparison CCDF of PAPR using Partial Transmit Sequence (PTS) technique with M=2, 4,8, 16,32 of sub blocks and Number of subcarriers N=256. Fig. 7 shows the comparison CCDF of PAPR using Partial Transmit Sequence (PTS) technique with different values of sub blocks and Number of subcarriers N=256.

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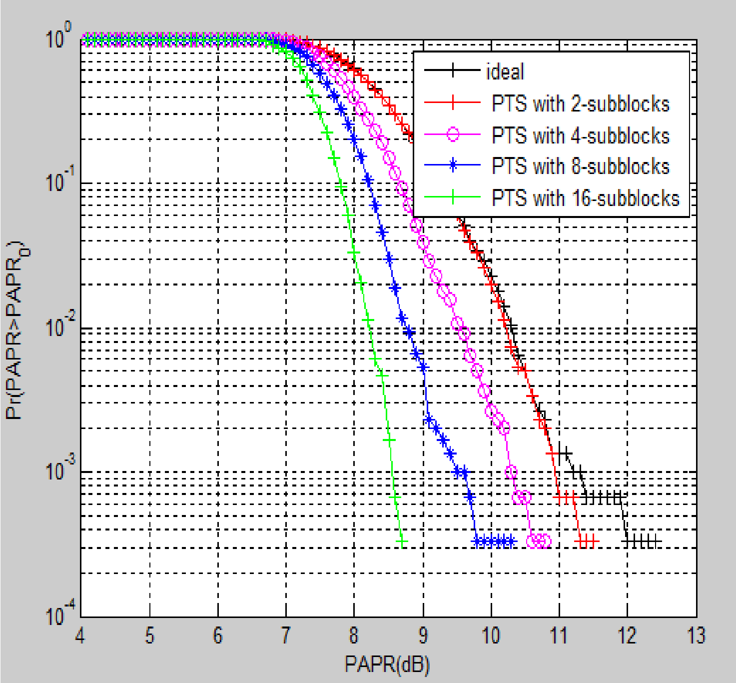

Fig. 5 comparison CCDF of PAPR using Partial Transmit Sequence (PTS) technique with M=2, 4, 8, 16 of sub blocks

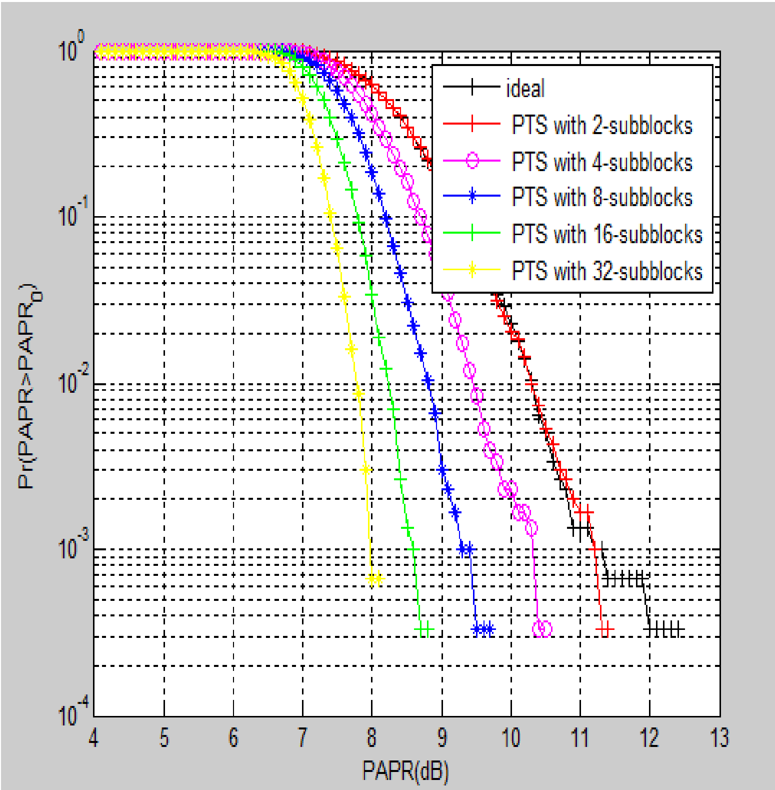

Fig. 6 comparison CCDF of PAPR using Partial Transmit Sequence (PTS) technique with M=2, 4, 8, 16, 32 of sub blocks

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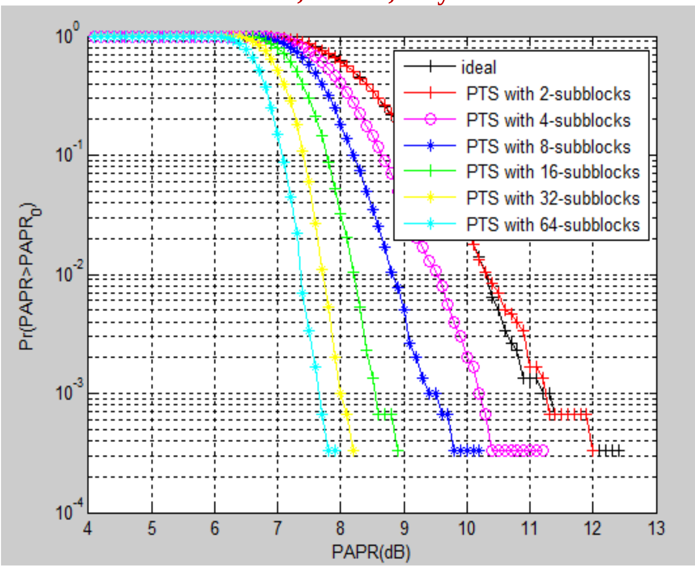

Fig. 7 Comparison of CCDF of PAPR in Partial Transmit Sequence (PTS) technique versus original technique with M=2, 4, 8, 16, 32 sub blocks

VI. CONCLUSIONS

In this paper, we present the peak-to-average power (PAPR) reduction in multicarrier transmission based on partial transmit Sequence (PTS Simulation result show that as the number of sub blocks increases, the performance of the channel goes on improving. The simulation results reveal that the PTS technique outperforms the other signal scrambling techniques. The performance of the PTS in frequency selective channel is studied with perfect channel information.

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